11:06:37 OCA PAD INITIATION - PROJECT HEADER INFORMATION 09/19/89

SUB UNDER E-21-T33

Active

Project #: A-8462 Cost share #: E-302-301 Rev #: 0
Center # : 246-R6583-000 Center shr #: 22-1-F6583-000 OCA file #: 128
Work type : RES
Contract#: F30602-88-D-0025-0033 Mod #: Document : DO
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #: E-21-T33

Project unit: SEL-ESMD Unit code: 01.021.363
Project director(s):
WILLOUGHBY R E SEL-ESMD (404)894-7107

Sponsor/division names: AIR FORCE / GRIFFISS AFB, NY
Sponsor/division codes: 104 / 023

Award period: 890907 to 900907 (performance) 901007 (reports)

Sponsor amount	New this change	Total to date
Contract value	67,900.00	67,900.00
Funded	67,900.00	67,900.00
Cost sharing amount		7,544.00

Does subcontracting plan apply ?: Y

Title: SEI PROCESSOR CALIBRATION

PROJECT ADMINISTRATION DATA

OCA contact: Brian J. Lindberg 894-4820

Sponsor technical contact

WILLIAM C. ZIESENITZ

ROME AIR DEVELOPMENT CENTER/IRAP
GRIFFISS AFB, NY 13441-5700

Sponsor issuing office

GERARD BROWN
(315)330-7060
ROME AIR DEVELOPMENT CENTER
DIRECTORATE OF CONTRACTING (PKRM)
GRIFFISS AFB, NY 13441-5700

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): Y
Defense priority rating : DO-A7 GOV'T supplemental sheet
Equipment title vests with: Sponsor X GIT
SEE SECTION H OF DELIVERY ORDER FOR INFORMATION ON GOV'T FURNISHED PROPERTY

Administrative comments -
INITIATION OF TASK I-9-4199 UNDER E-21-T33/JOY. ALL REPORTS ARE TO BE SUBMITTED UNDER MAIN PROJECT (SEE LORI ROSE IN EE FOR ADDITIONAL INFORMATION)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 04/19/91

Project No. E-21-T33 Center No. 10/24-6-R6583-T33

Project Director JOY E B School/Lab ELEC ENGR

Sponsor AIR FORCE/GRIFFISS AFB, NY

Contract/Grant No. F30602-88-D-0025-0033 Contract Entity GTRC

Prime Contract No. ____

Title SEI PROCESSOR CALIBRATION

Effective Completion Date 900907 (Performance) 901007 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	Y	
Other ____	N	

Comments ____

Subproject Under Main Project No. ____

Continues Project No. ____

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other ____	N
____	N

NOTE: Final Patent Questionnaire sent to PDPI.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT (SUBPROJECTS)

Closeout Notice Date 04/19/91

Project No. E-21-T33 Center No. 10/24-6-R6583-T33_

Project Director JOY E B_______________ School/Lab ELEC ENGR_____

Sponsor AIR FORCE/GRIFFISS AFB, NY______________________________

Project # A-8462 PD WILLOUGHBY R E Unit 01.021.333 T
DO # F30602-88-D-0025-003 MOD# ESML *
Ctr # 246-R6583-000 Main proj # E-21-T33 OCA CO BJL
Sponsor-AIR FORCE /GRIFFISS AFB, NY 104/023
SEI PROCESSOR CALIBR
Start 890907 End 900907 Funded 67,900.00 Contract 67,900.00

LEGEND
1. * indicates the project is a subproject.
2. I indicates the project is active and being updated.
3. A indicates the project is currently active.
4. T indicates the project has been terminated.
5. R indicates a terminated project that is being modified.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 04/19/91

Project No. A-8462 Center No. 246-R6583-000

Project Director WILLOUGHBY R E School/Lab ESML

Sponsor AIR FORCE/GRIFFISS AFB, NY

Contract/Grant No. F30602-88-D-0025-0033 Contract Entity GTRC

Prime Contract No.

Title SEI PROCESSOR CALIBRATION

Effective Completion Date 900907 (Performance) 901007 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	N	
Final Report of Inventions and/or Subcontracts	N	
Government Property Inventory & Related Certificate	N	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments

Subproject Under Main Project No. E-21-T33

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	N
GTRC	Y
Project File	Y
Other	N
	N

CONTRACT FUNDS STATUS REPORT (DD FORM 1586)
CONTRACT NUMBER F30602-88-D-0025
QUARTER: OCT-DEC '89

CURRENT QUARTER FUNDING				$292,994.00
DO #	0001	$9,000	C-8-2129	
	0011	$19,568	C-8-2400	
	0012	$24,700	C-8-2402	
	0015	$29,783	C-9-2015	
	0016	$31,250	A-9-1120	
	0018	$12,000	E-9-7093	
	0019	$62,000	C-9-2109	
	0022	$54,693	C-9-2404	
	0028	$50,000	N-9-5308	
		$292,994		

CURRENT QUARTER EXPENDITURES	$286,691.16
CONTRACT CEILING	$4,200,000.00
FUNDING TO DATE	- $2,322,669.00
* PENDING COMMITMENTS	- $595,000.00
AVAILABLE FUNDING	$1,282,331.00
FUNDING TO DATE	$2,322,669.00
YTD EXPENDITURES	- $1,136,142.64
OUTSTANDING EXPENDITURES	$1,186,526.36

* DO #	0007	S-8-7592 INCREMENTAL FUNDING	$20,000.00
	0029	E-9-7119 INCREMENTAL FUNDING	$60,000.00
	0030	N-9-5317 INCREMENTAL FUNDING	$20,000.00
	0034	N-9-5314 INCREMENTAL FUNDING	$15,000.00
	0016	N-9-5315 INCREMENTAL FUNDING	$30,000.00
	N-0-5703	UNIV OF SOUTHERN FLA/WILSON	$50,000.00
	A-0-1102	UNIV OF CA/SMOOT, BARBER, GT	$100,000.00
	P-0-6011	NCSU/VANDERLUGT	$100,000.00
	C-0-2456	NEW JERSEY INST/BAR-NESS	$100,000.00
	P-0-6014	STEVENS INST/ZMUDA	$100,000.00
		TOTAL PENDING	$595,000.00

WAITING FOR PROPOSALS:

P-0-6018	UAH/CAULFIELD
P-0-6021	GT/SUMNERS
P-0-6022	CORNELL UNIV/TANG
B-0-3353	ROCHESTER INST/LASKY

CONTRACT FUNDS STATUS REPORT (DD FORM 1586)
CONTRACT NUMBER F30602-88-D-0025
QUARTER: JAN-MAR '90

CURRENT QUARTER FUNDING				$114,301.00
DO # 0007	$9,000	S-8-7592		
0029	$19,568	E-9-7119		
0030	$24,700	N-9-5317		
0036	$29,783	P-0-6014		
0037	$31,250	P-0-6011		

	$114,301			

CURRENT QUARTER EXPENDITURES		$376,743.62
CONTRACT CEILING		$4,200,000.00
FUNDING TO DATE	-	$2,436,970.00
* PENDING COMMITMENTS	-	$532,800.00

AVAILABLE FUNDING		$1,230,230.00
FUNDING TO DATE		$2,436,970.00
YTD EXPENDITURES	-	$1,512,886.26

OUTSTANDING EXPENDITURES		$924,083.74

* DO# 0034	N-9-5314	INCREMENTAL FUNDING	$15,000.00
0035	N-9-5315	INCREMENTAL FUNDING	$30,000.00
0037	P-0-6011	INCREMENTAL FUNDING	$10,000.00
N-0-5703	UNIV OF SOUTHERN FLA/WILSON		$50,000.00
A-0-1402	UNIV OF CA/SMOOT, BARBER, GT		$100,000.00
C-0-2456	NEW JERSEY INST/BAR-NESS		$100,000.00
P-0-6021	GT/SUMNERS		$100,000.00
P-0-6022	CORNELL UNIV/TANG		$30,800.00
B-0-3353	ROCHESTER INST/LASKY		$20,000.00
P-0-6018	UAH/CAULFIELD		$77,000.00

TOTAL PENDING			$532,800.00

WAITING FOR PROPOSALS:
P-0-6018 UAH/CAULFIELD
P-0-6021 GT/SUMNERS
P-0-6022 CORNELL UNIV/TANG
B-0-3353 ROCHESTER INST/LASKY

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

TELEPHONE: (404) 894-

July 24, 1990

MEMORANDUM

TO: Jim Wasielewski
Expert Science & Engr. Program
RADC/RBC
Griffiss AFB, NY 13441

FROM: Lori Parker, LP Research Administrator

SUBJECT: Contract Funds Status Reports for
Qtr. Ending 6/30/90
CONTRACT # F30602-88-D-0025

Attached are four copies of subject above as required by the contract. Please call if you have questions or need additional information.

CONTRACT FUNDS STATUS REPORT (DD FORM 1586)
CONTRACT NUMBER F30602-88-D-0025
QUARTER: APR-JUN'90

CURRENT QUARTER FUNDING			$155,554.00
DO # 0038	$50,000	P-0-6018	
0039	$30,800	P-0-6022	
0040	$55,000	P-0-6021	
0042	$19,754	B-0-3353	
	$155,554		

CURRENT QUARTER EXPENDITURES		$347,767.26
CONTRACT CEILING		$4,200,000.00
FUNDING TO DATE	-	$2,768,223.00
* PENDING COMMITMENTS	-	$432,127.00
AVAILABLE FUNDING		$999,650.00
FUNDING TO DATE		$2,768,223.00
YTD EXPENDITURES	-	$1,860,653.52
OUTSTANDING EXPENDITURES		$907,569.48

* DO# 0034	N-9-5314	INCREMENTAL FUNDING	$15,000.00
0035	N-9-5315	INCREMENTAL FUNDING	$30,000.00
0037	P-0-6011	INCREMENTAL FUNDING	$10,000.00
0038	P-0-6018	INCREMENTAL FUNDING	$27,000.00
0040	P-0-6021	INCREMENTAL FUNDING	$43,127.00
N-0-5703	UNIV OF SOUTHERN FLA/WILSON		$50,000.00
A-0-1402	UNIV OF CA/SMOOT, BARBER, GT		$100,000.00
C-0-2456	NEW JERSEY INST/BAR-NESS		$100,000.00
E-0-7118	FRANKENTHAL		$24,000.00
I-9-4198	GA TECH/WILLOUGHBY		$33,000.00
TOTAL PENDING			$432,127.00

WAITING FOR PROPOSALS: None

E-21-T33

ROME AIR DEVELOPMENT CENTER
EXPERT SCIENCE AND ENGINEERING PROGRAM
CONTRACT NO. F30602-88-D-0025

R & D STATUS REPORT

PERIOD COVERED: 7 Sept. 89 - 31 Dec. 89

TASK NUMBER: E-21-T33 and E-21-T32

TITLE: SEI Processor Calibration and Simultaneous Air/Ground Collections

PRINCIPAL INVESTIGATOR: R. E. Willoughby

INSTITUTION: Georgia Institute of Technology

OTHER PARTICIPANTS AND TITLES:

Colin Field RE1
W. Scott Petty SRE

A. TECHNICAL PROGRESS ACHIEVED ON EFFORT:

During the first quarter the principal activity on Task T-33 centered around the receiving, setting up, checking out, and operating the RADC collection system which was furnished as GFE to the program. The equipment was delivered personally to GTRI by Mr. William Ziesenitz and Lt. Darren Kaneshiro of RADC on 15 November, 1989. Mr. James Dowd of NSA accompanied them on that visit and a planning and orientation meeting was held. It was decided that after GTRI personnel had become familiar with the operation of the RADC equipment, Lt. Kaneshiro would return to Atlanta to participate in a preliminary collection exercise in which both systems would be placed on the GTRI collection van and taken to a nearby site, probably near Hartsfield International Airport, and data as nearly identical as possible taken with each system so that comparisons can be made to determine whether or not the joint Air/Ground exercise can be expected to yield useful information.

The RADC equipment was set up, and after some problems in acquiring the proper cables, was successfully operated in the laboratory. Attention was then turned to the preparation of software to convert the data collected on the RADC system to the format required by the GTRI analysis software. This software was completed in early December and tentative plans were made for Lt. Kaneshiro to visit GTRI the week of 8 January, 1990.

No effort has been expended as yet on task T-32.

B. TRAVEL:

None.

C. PRESENTATIONS AND PUBLICATIONS:

None.

D. LEVEL OF EFFORT BY EACH CONTRIBUTOR (IN MAN-MONTHS OR MAN-HOURS)

R. E. Willoughby	0.3 MM
C. J. Field	0.2 MM
W. Scott Petty	0.1 MM

E-21-T33

ROME AIR DEVELOPMENT CENTER
EXPERT SCIENCE AND ENGINEERING PROGRAM
CONTRACT NO. F30602-88-D-0025

R & D STATUS REPORT

PERIOD COVERED: 1 April 90 - 30 June 90

TASK NUMBER: E-21-T33 and E-21-T32

TITLE: SEI Processor Calibration and Simultaneous Air/Ground Collections

PRINCIPAL INVESTIGATOR: R. E. Willoughby

INSTITUTION: Georgia Institute of Technology

OTHER PARTICIPANTS AND TITLES:

Colin Field	RE1
W. Scott Petty	SRE
J.H. Bordelon	SRE
S.P. Malone	ET2

A. TECHNICAL PROGRESS ACHIEVED ON EFFORT:

A review meeting was held at Georgia Tech on April 24. In attendance from RADC were Mr. William Ziesenitz and Lt. Darren Kaneshiro. Results of investigation of data portability between the TEDSS data collection system and the RADC data collection system were presented. Georgia Tech personnel concluded that data portability was questionable between the two systems and presented three options for the next quarter's efforts: (1) proceed with the current systems in acquiring simultaneous air/ground data, (2) construct two special purpose receivers for the simultaneous air/ground data collection, or (3) continue investigation into system coloration and difference. Mr. Ziesenitz indicated that he would like Georgia Tech to pursue option 2, construct two special purpose receivers to be used in the simultaneous air/ground collection.

Soon after the review meeting, work began on designing the receivers to maximize system phase linearity and identifying "off-the-shelf" parts to minimize material costs.

The phase linearity concern drove the system architecture design and filter selection. A block diagram is shown in figure 1. The receiver design encompasses two down conversion steps to minimize mixer coloration and obtain an output at 50 MHz. A three stage design would have allowed for wider filters in the front end, providing better phase specifications, but having the disadvantage of the potential for coloration because of the additional mixer and local oscillator. It was decided that minimizing the number of down conversions would produce better results. A lab signal source will operate as the first local oscillator to minimize cost to the project. The second local oscillator will be a commercial crystal oscillator.

The receiver design contains four filters. The front-end bandpass filter exhibits a Butterworth response and 145 MHz of bandwidth. The receiver input is filtered to provide image rejection. The filter was chosen as a balance between phase linearity, frequency coverage, and image rejection. Receiver frequency coverage is set by this front-end bandpass filter. Two bandpass filters were purchased to allow coverage of the Dobbins Air Force Base approach radar and the TPS-43E radar at McCollum field.

The filter after the first downconversion stage is a Surface Acoustic Wave band pass filter. The SAW filter exhibits a linear phase response and sharply sets the receiver bandwidth to 50 MHz. In addition, this SAW device will remove the necessity of using coaxial delay lines that are currently employed in the RADC and TEDSS collection systems. The filter has a 500 nanosecond delay due to acoustic wave propagation and this delay will be utilized in triggering the Lecroy digitizers. The selection of the first I.F. was driven by the availability of a SAW filter with a 50 MHz bandwidth. The only one found was designed for 175 MHz center frequency. Hence the first I.F. is 175 MHz.

The filter between the second local oscillator and second mixer provides harmonic suppression for the crystal local oscillator. The crystal oscillator outputs spurs at approximately 70 MHz, 140 MHz and multiples of the intended 225 MHz. The harmonic suppression filter has a bandwidth of 20 MHz centered around 225 MHz.

The fourth filter is located at the output of the second mixing stage. This is low pass filter, chosen to balance phase linearity and local oscillator rejection. It has a 3dB cutoff frequency of 125 MHz.

Overall the receiver employs wideband amplifiers to minimize phase colorations. The I.F. amplifiers possess a 500 Mhz bandwidth and are phase linear over a good portion of this band.

Currently, Georgia Tech has ordered all the parts and received all parts except for one microwave amplifier and the filters for the crystal local oscillators. These parts are due in July.

By July 20, all parts on hand will be mounted in the chassis and the wiring harness completed. Semi-rigid work will begin Monday July 23. Testing will start as soon as the final parts arrive and are wired into place.

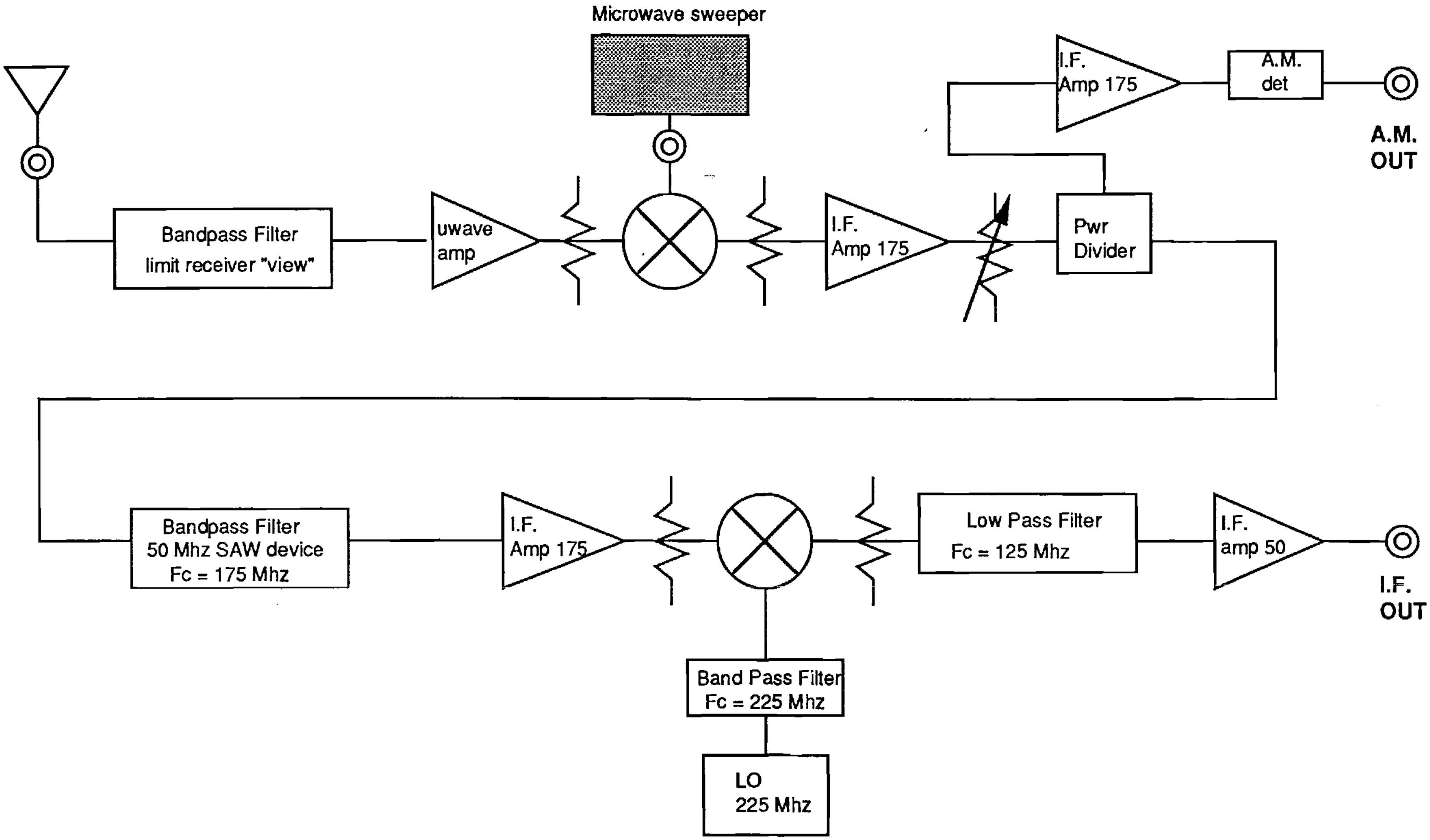


FIGURE 1

RECEIVER BLOCK DIAGRAM

B. TRAVEL:

None.

C. PRESENTATIONS AND PUBLICATIONS:

None.

D. LEVEL OF EFFORT BY EACH CONTRIBUTOR (IN MAN-MONTHS OR MAN-HOURS)

R. E. Willoughby	0.55 MM
C. J. Field	0.29 MM
W. Scott Petty	0.05 MM
J. H. Bordelon	0.43 MM
S. Malone	0.28 MM

L 31 7 32

ROME AIR DEVELOPMENT CENTER
EXPERT SCIENCE AND ENGINEERING PROGRAM
CONTRACT NO. F30602-88-D-0025

R & D STATUS REPORT

PERIOD COVERED: 1 July 90 - 30 September 90

TASK NUMBER: E-21-T33 and E-21-T32

TITLE: SEI Processor Calibration and Simultaneous Air/Ground Collections

PRINCIPAL INVESTIGATOR: R. E. Willoughby

INSTITUTION: Georgia Institute of Technology

OTHER PARTICIPANTS AND TITLES:

Larry D. Holland	PRE
Colin Field	RE1
Walter Haines	RE1
John Bordelon	SRE
Shawn Malone	ET2
John Wolfe	ET
Richard Everett	SA
Suzy Chen	GRA

A. TECHNICAL PROGRESS ACHIEVED ON EFFORT:

The construction and testing of the two special purpose receivers was completed during the reporting period. A review meeting was held at Georgia Tech on August 24. In attendance from RADC were Mr. William Ziesenitz and Lt. Darren Kaneshiro. Preliminary results of investigation of data portability between the two special receivers were presented. This investigation was based primarily on the analysis performed on the data generated by feeding signals from the Advanced Radar Signal Generator (ARSG) to each of the receivers followed by a Lecroy waveform digitizer. The digitized signals were processed using software developed on contract Number FF33615-88-C-1728, Task V-2/3 for Wright Research and Development Center. A more detailed analysis of the output of the two receivers was conducted in the latter part of the reporting period, and it appears that the difference between the two receivers is much smaller than the difference previously observed between the two Microtel receivers.

A more detailed discussion of this analysis will be presented in a technical memorandum which will be submitted during the next quarter.

The simultaneous air/ground collection is scheduled to take place on October 30. Two emitters will be collected, Dobbins Air Force Base approach radar and the TPS-43E radar at McCollum field. RADC personnel are scheduled to be present to observe and/or participate in the exercise.

Task E-21-T33 ended 30 September, but Task E-21-T32 has been modified to continue through 31 December. This modification was necessary to allow time to construct the two special purpose receivers, which were not planned in the original Statement of Work. Sufficient time is in the present schedule to evaluate the data scheduled to be gathered on 30 October. Hopefully, this evaluation will provide guidance as to the next needed step to asses the magnitude of the receiver coloration problem and to find a realistic solution.

B. TRAVEL:

None.

C. PRESENTATIONS AND PUBLICATIONS:

None.

D. LEVEL OF EFFORT BY EACH CONTRIBUTOR (IN MAN-MONTHS OR MAN-HOURS)

R. E. Willoughby	0.68 MM
C. J. Field	0.65 MM
W. Haines	0.09 MM
J. H. Bordelon	0.14 MM
S. Malone	0.58 MM
L. Holland	0.03 MM
R. Everett	0.10 MM
S. Chen	0.01 MM
J Wolfe	0.01 MM

E-21-T33

ROME AIR DEVELOPMENT CENTER
EXPERT SCIENCE AND ENGINEERING PROGRAM
CONTRACT NO. F30602-88-D-0025

R & D STATUS REPORT

PERIOD COVERED: 1 Jan. 90 - 31 Mar. 90

TASK NUMBER: E-21-T33 and E-21-T32

TITLE: SEI Processor Calibration and Simultaneous Air/Ground Collections

PRINCIPAL INVESTIGATOR: R. E. Willoughby

INSTITUTION: Georgia Institute of Technology

OTHER PARTICIPANTS AND TITLES:

Colin Field RE1
W. Scott Petty SRE

A. TECHNICAL PROGRESS ACHIEVED ON EFFORT:

Georgia Tech began this quarter by collecting data with both the TEDSS data collection system and the RADC collection system simultaneously. The data collected were in three main categories. In each collection exercise, the two systems were connected to the signal source or microwave horn antenna by a wideband 10 dB coupler.

Pulsed data were first taken from a Hewlett Packard microwave signal generator at several frequencies. The signal generator data were to be used as a baseline. The generator uses pin diode switches to perform the pulsing operation at switching speeds no greater then 40 nanoseconds. This source was viewed as a source of a clean waveform, with minimum frequency modulation. This data will be referred to in this report as Type 1 data.

Next, the two systems were taken to Atlanta's Hartsfield airport to take data from the airport surveillance radar, ASR-7. Lt. Kaneshiro from RADC participated in this data collection exercise. The ASR-7 radar employs a klystron as its RF power amplifier, and transmits on one of two frequencies. GTRI collected data at 2840 MHz with both systems. The data were acquired through a microwave horn antenna set up approximately 500 yards from the ASR-7 dish. This data will be referred to in this report as Type 2 data.

The third type of data were taken in the lab from the Hewlett Packard microwave signal generator. This collection was performed in a manner similar to the first collection exercise, with the single exception that both collection systems had the YIG preselector filters bypassed. The bandpass filter formed by tunable YIG cavities has been viewed as a potential source of coloration. The extent of the coloration has been debated numerous times. This data will be referred to in this report as Type 3 data.

Data from all three sets were plotted out in several formats for visual comparison. Two formats included in this report are:

1) AMCOMPUL
   The average and standard deviation of the A.M. waveforms in a file are calculated and plotted.

2) COMPUL
   The average and standard deviation of the F.M. waveforms in a file are calculated and plotted.

Figure 1 portrays Type 1 data taken at 2 GHz. Figures 1A and 1B are AMCOMPUL plots. Figures 1C and 1D are COMPUL plots.

Figure 2 displays Type 2 data taken from the ASR-7 at 2840 MHz. Figures 2A and 2B are AMCOMPUL plots. Figures 2C and 2D are COMPUL plots.

Figure 3 shows Type 3 data taken from the signal generator at 2 GHz with the YIG preselectors bypassed. Figures 3A and 3B are AMCOMPUL plots. Figures 3C and 3D are COMPUL plots.

The COMPUL (i.e. F.M.) plots show some obvious differences in the F.M. waveforms between the systems for each of the three data types. Because of the obvious differences, the initial investigation centered on discovering the reasons for the data dissimilarity. The data used in the initial investigation was mainly of Type 1 signal generator data. Figure 4 shows a diagram of the data flow for both systems.

Georgia Tech's F.M. demodulation software, IFDEMOD, was the first item in the data path to be investigated. IFDEMOD was investigated to rule out the possibility that the demodulation code was processing the two I.F. signals differently. The investigation involved the use of the software math and signal processing package MATLAB. The IFDEMOD code was simulated in MATLAB, and Type 1 data from the two collection systems were run through the simulated code; the simulation results were similar to the results from the IFDEMOD code itself. The next step involved generating a zero-crossing detector for demodulation in MATLAB. The results from the zero-crossing detector also concurred with the previous results. Hence at this point it was assumed that F.M. portrayed by IFDEMOD was actually in the I.F. digitized waveform.

Since the F.M. appears to be in the digitized data, the investigation turned upstream. The next potential coloration source examined was the delay line compensation (Figure 4). Georgia Tech filters TEDSS' data to compensate for the non-constant attenuation v.s. frequency of the delay line. The RADC system, on the other hand, does not attempt to compensate for the delay line. So a simple equalization software filter was designed in MATLAB for the RADC delay line. The filter was of a symmetric design type, which guarantees a linear phase response. The delay line was swept in frequency, and the output was recorded by a spectrum analyzer to obtain the magnitude response used in the filter design. The RADC data of Type 1 were then filtered and demodulated in MATLAB. The interesting result was that the F.M. at the edges of the pulse, "edge F.M.", changed significantly. Figures 5A and 5B show the before and after cases respectively. This implied that the frequency modulation on pulse (FMOP) was sensitive to the shape of the passband response.

At this point, it was decided to work with the Type 3 data, no-YIG-preselectors case. Even without the preselectors, the edge F.M. of the two systems at the same frequency was different. So spectrum analyzer plots of the receivers' passbands were generated. Figure 6A shows the passband response at 15 GHz for the RADC system at the 250 MHz I.F. output and Figure 6B shows the passband response for the TEDSS system at the 160 MHz I.F. output. Also, Figures 7A and 7B show the responses at 2 GHz. These plots show differences in the passband slope and ripple. These differences are on the order of 1 to 2 dB and normally considered to be insignificant. But the equalization filter described above was on this order and changed the edge F.M. significantly.

The receivers' passbands appear different at several center frequencies that were checked across the 2 to 15 GHz band. It must be assumed in general that one would need a transform for each center frequency at which data were procured. To this end, a correlation technique was attempted that had been suggested by Dr. Jim Lansford. Briefly, the technique involved taking time-coincident pulses from the two systems. First an FFT was performed on the two pulses, the magnitudes of the coefficients were normalized, and the phase difference of the coefficients was obtained by subtraction. This resulted in a magnitude transform vector and a phase transform vector. Then an FFT was taken on the pulse to be transformed. The designated pulse's magnitude terms were multiplied by the magnitude transform vector and the designated pulse's phase terms were added to the phase transform vector to generate the FFT coefficients for the transformed pulse. These FFT coefficients were then run through an inverse FFT in an attempt to obtain the transformed pulse I.F. waveform. But the results were less than encouraging. After several approaches were tried, the method was dropped. The method was judged not feasible in this case, primarily because of the difficulty caused by phase differences in the two digitized waveforms resulting from the 5 nanosecond sampling interval.

At this juncture, some software modeling was undertaken. Several linear phase software filters were generated in MATLAB. These filters represented several different passbands with different slopes. Code was also written to generate sampled waveforms at any I.F., with any rise time, with or without F.M. and with different phase sample start points. The software pulses were then run through the different filters and then demodulated. The interesting result of these runs was the fact that clean pulses (no F.M.) were affected significantly by the filtering operation. The edge F.M. of the clean pulses was negligible before filtering and noticeable after filtering. Conversely, the pulses with significant FMOP showed little difference between the before and after filtering cases. These test case results support the generally held conception that the small passband ripple and slope do not seriously degrade the FMOP.

With this discovery, the Hartsfield data were re-examined. A sample RADC file was filtered with one of the passband simulators to examine the effect on the FMOP. As expected at this point, the passband filter software simulator had little effect on the FMOP. But there still existed some difference between the systems' data in the magnitude of the F.M. swing at the pulse edges and within the pulse itself. So the question was: "If this edge F.M. difference cannot be explained by passband slope/ripple, what is causing the difference?" The next proposed answer was the bandwidth; RADC Hartsfield data were bandpass filtered to 40 MHz. The before and after plots of the F.M. are shown respectively in Figures 8A and 8B. One will notice that the F.M. shape has not changed.

But the eye is not a good judge of curve shape, so a confusion matrix was run using the minimum entropy feature extraction technique to determine whether or not the features were similar enough for the computer to group them together. A TEDSS file and the simultaneously obtained RADC file of Type 2 Hartsfield data were run against several libraries. The files that were compared against the libraries are labeled "Pulse Source" in the figures. Figure 9 shows a confusion matrix with a library containing three random files. Figure 11 shows a confusion matrix with a library containing the initial three random files and the TEDSS file i.d. vector for the TEDSS "Pulse Source" file. Figure 12 shows a confusion matrix with a library containing the initial random files and the RADC file i.d. vector for the RADC "Pulse Source" file. Figure 10 shows a confusion matrix with a library containing the initial random files and both the TEDSS and the RADC file i.d. vector for the "Pulse Source" files. The results would indicate that the RADC and TEDSS files are very similar but not identical. In fact, Figure 12 would indicate that there is some system bias because the TEDSS file identified more with a random TEDSS library entry than the RADC library entry consisting of simultaneously obtained data. Figures 13, 14, 15 show COMPUL data for the three random library entries.

Currently, Georgia Tech is awaiting the return of the TEDSS Micro-Tel receiver from factory repair. Investigations of system differences will continue in the next quarter. In addition, plans for the joint air/ground data collection exercise will be discussed with RADC representatives at a meeting to be held April 24 at GTRI.

B. TRAVEL:

None.

C. PRESENTATIONS AND PUBLICATIONS:

None.

D. LEVEL OF EFFORT BY EACH CONTRIBUTOR (IN MAN-MONTHS OR MAN-HOURS)

R. E. Willoughby	0.88 MM
C. J. Field	1.95 MM
W. Scott Petty	0.19 MM
M. M. Foreman	0.9MM
J. L. Lansford	0.1MM
K. L. Schlag	0.2MM

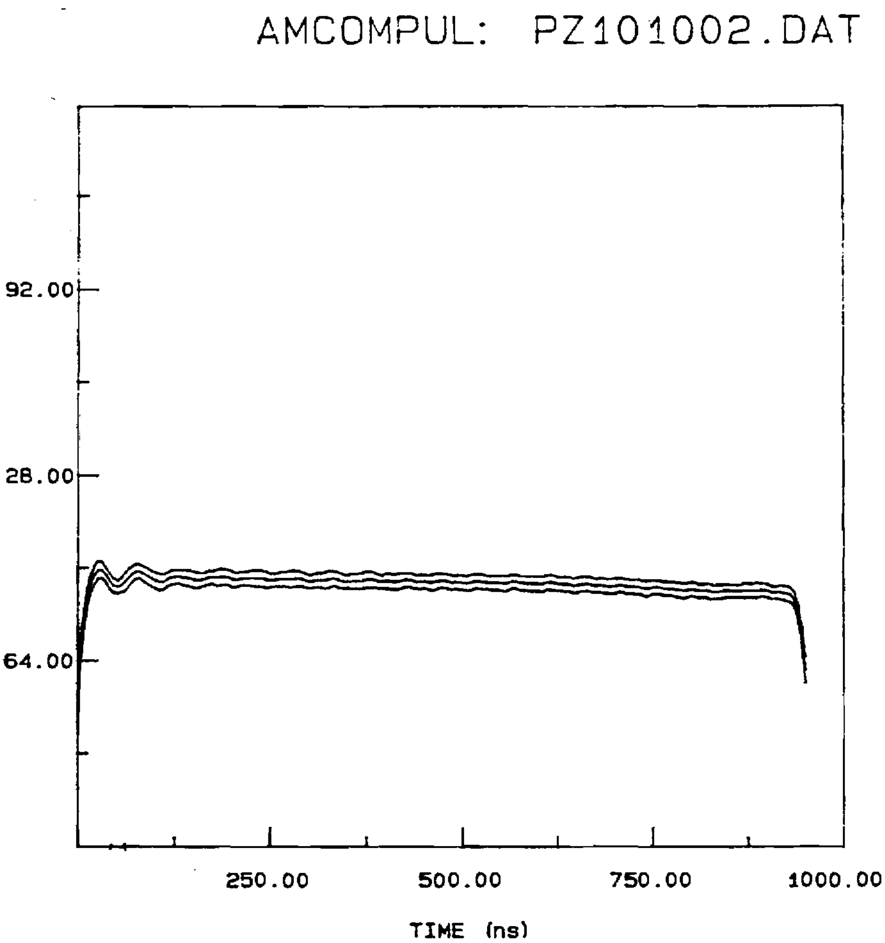


Figure 1A
- •TEDSS data
- •Software detected A.M.
- •Preselectors inline
- •2 Ghz RF input

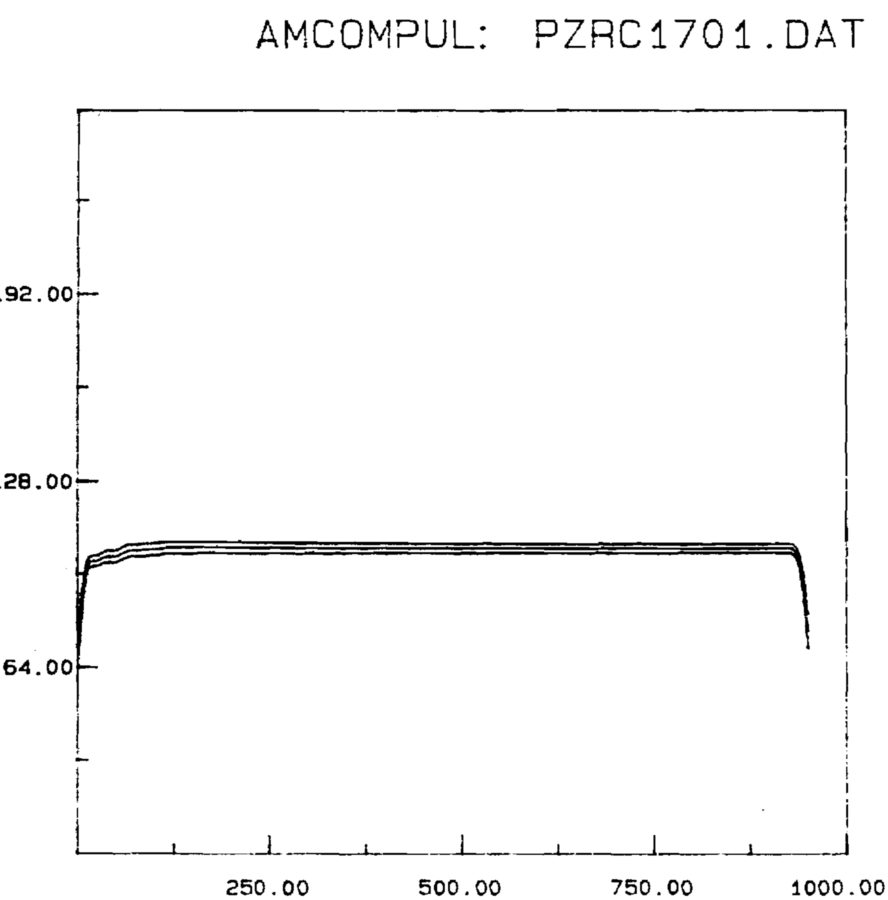


Figure 1B
- •RADC data
- •Software detected A.M.
- •Preselectors inline
- •2 Ghz RF input

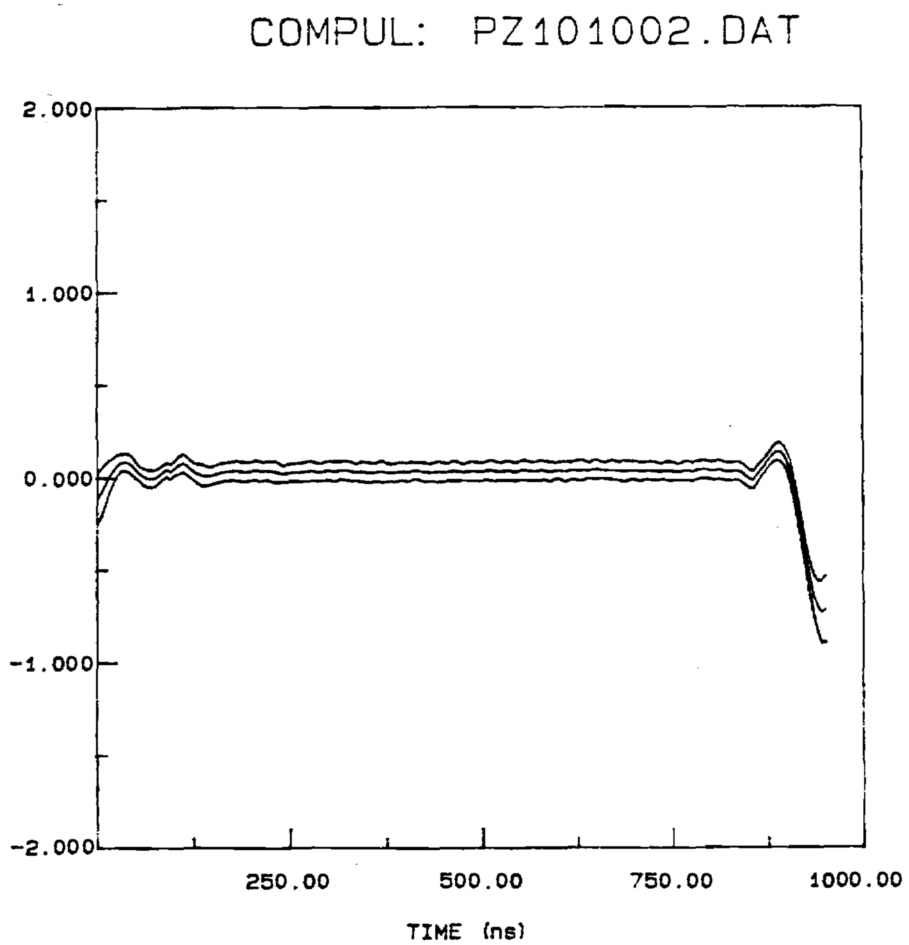


Figure 1C
- TEDSS data
- Software detected F.M.
- Preselectors inline
- 2 Ghz RF input

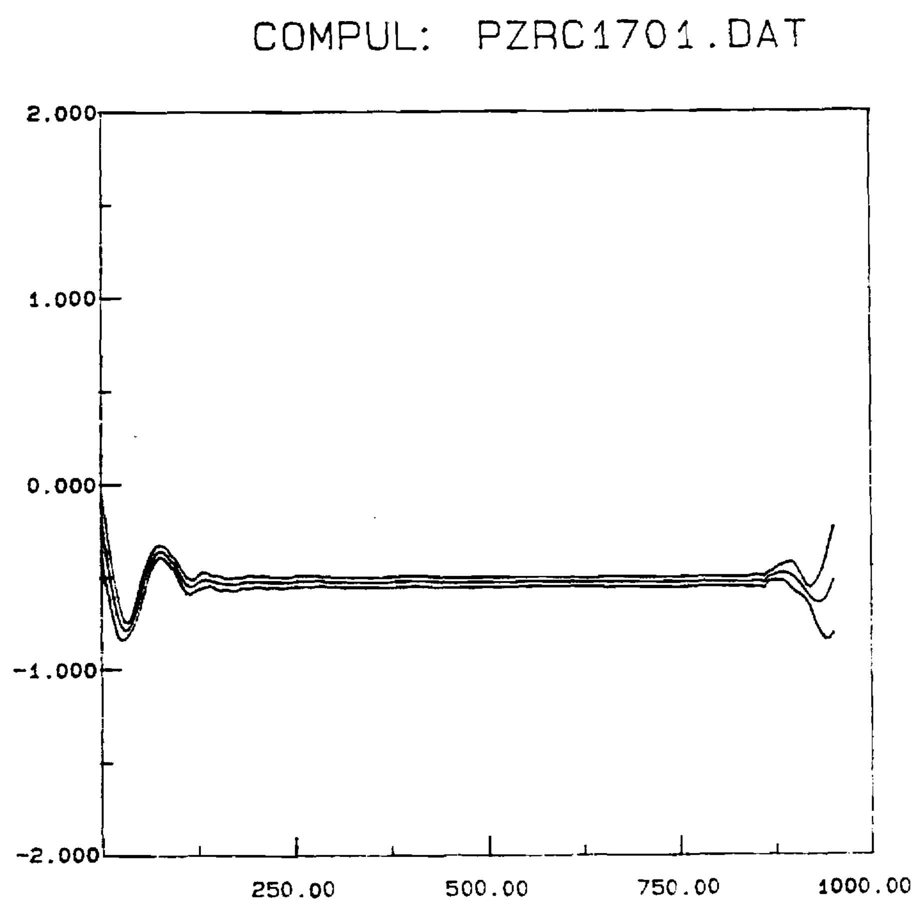


Figure 1D
- RADC data
- Software detected F.M.
- Preselectors inline
- 2 Ghz RF input

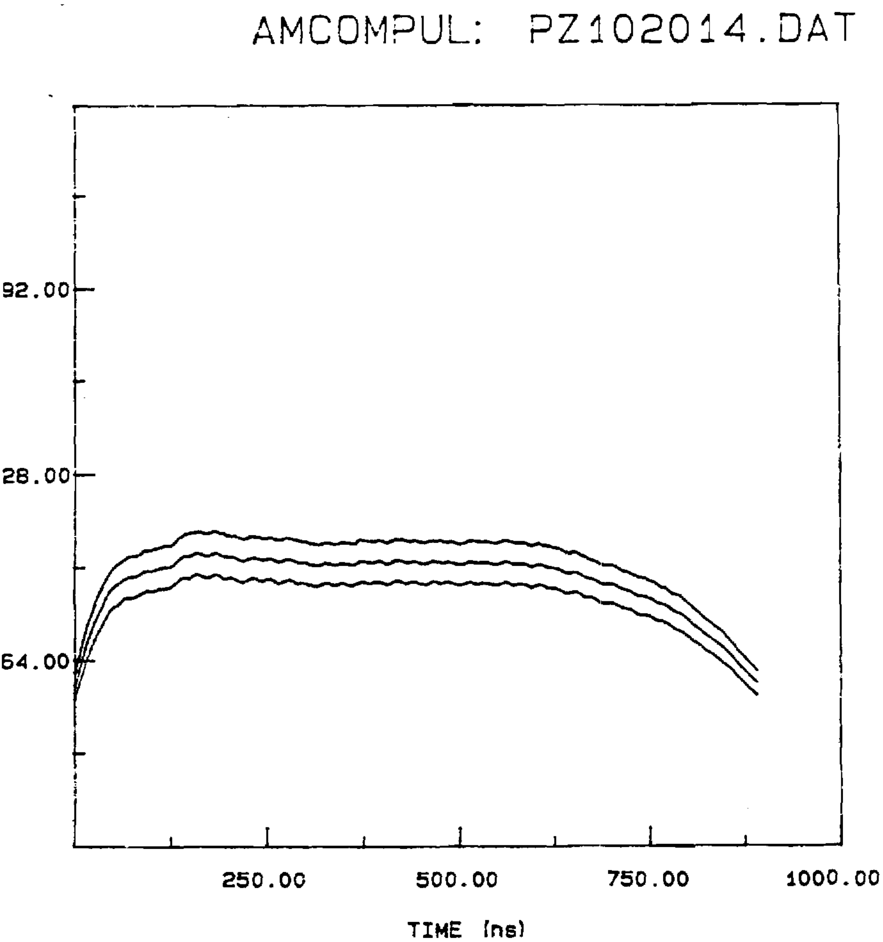


Figure 2A
•TEDSS data
•Software detected A.M.
•Preselectors inline
•2840 Mhz RF input

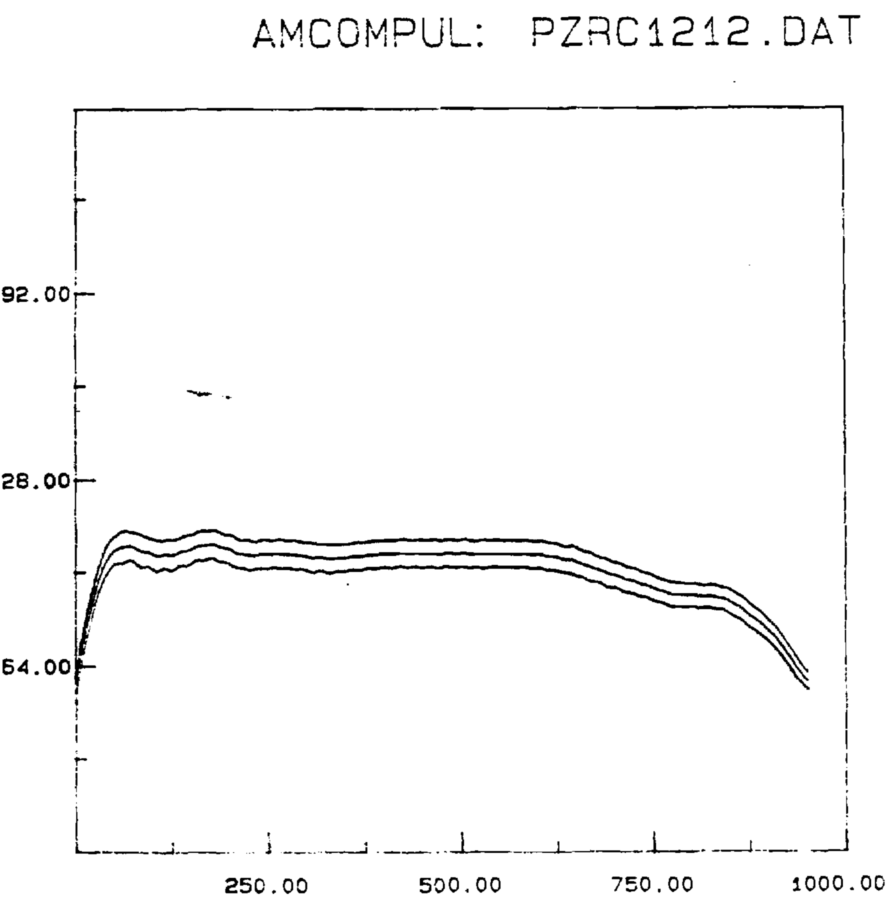


Figure 2B
•RADC data
•Software detected A.M.
•Preselectors inline
•2840 Mhz RF input

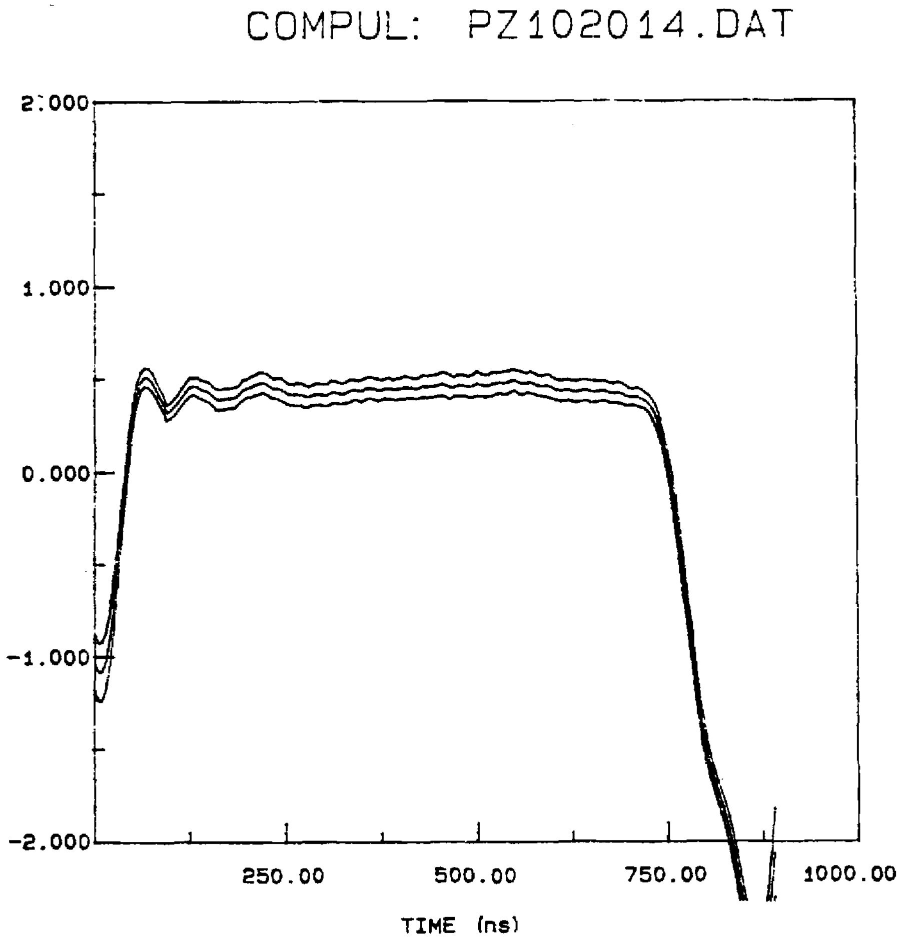


Figure 2C

- TEDSS data
- Software detected F.M.
- Preselectors inline
- 2840 Mhz RF input

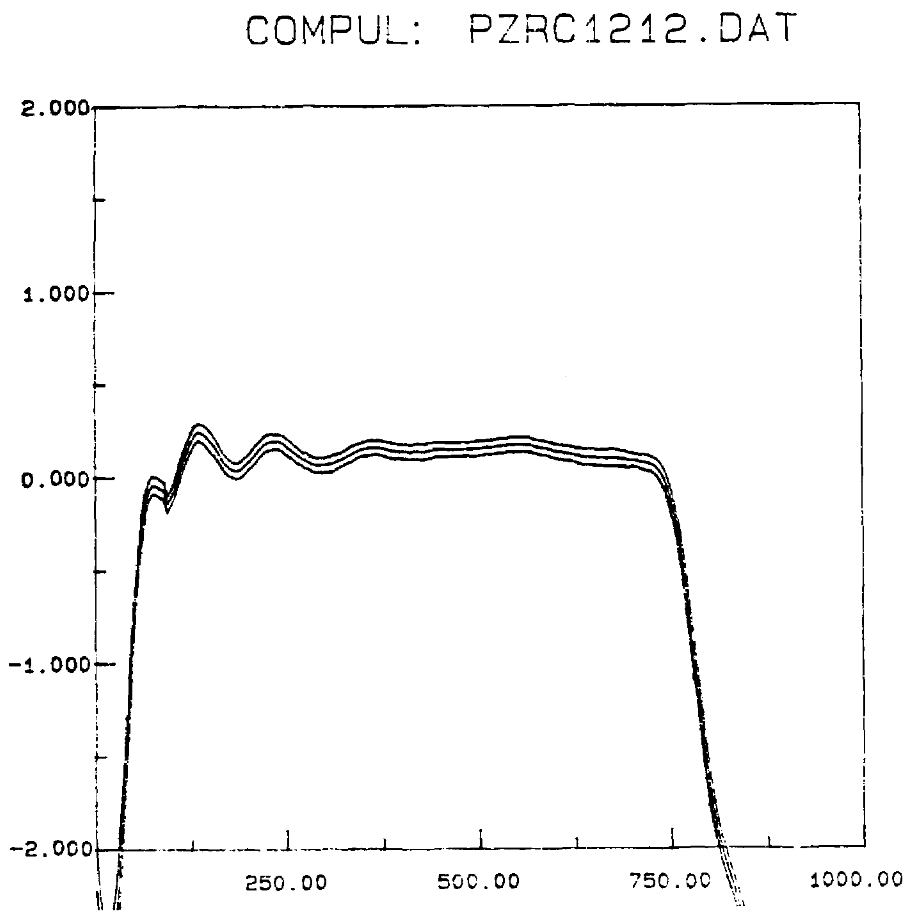


Figure 2D

- RADC data
- Software detected F.M.
- Preselectors inline
- 2840 Mhz RF input

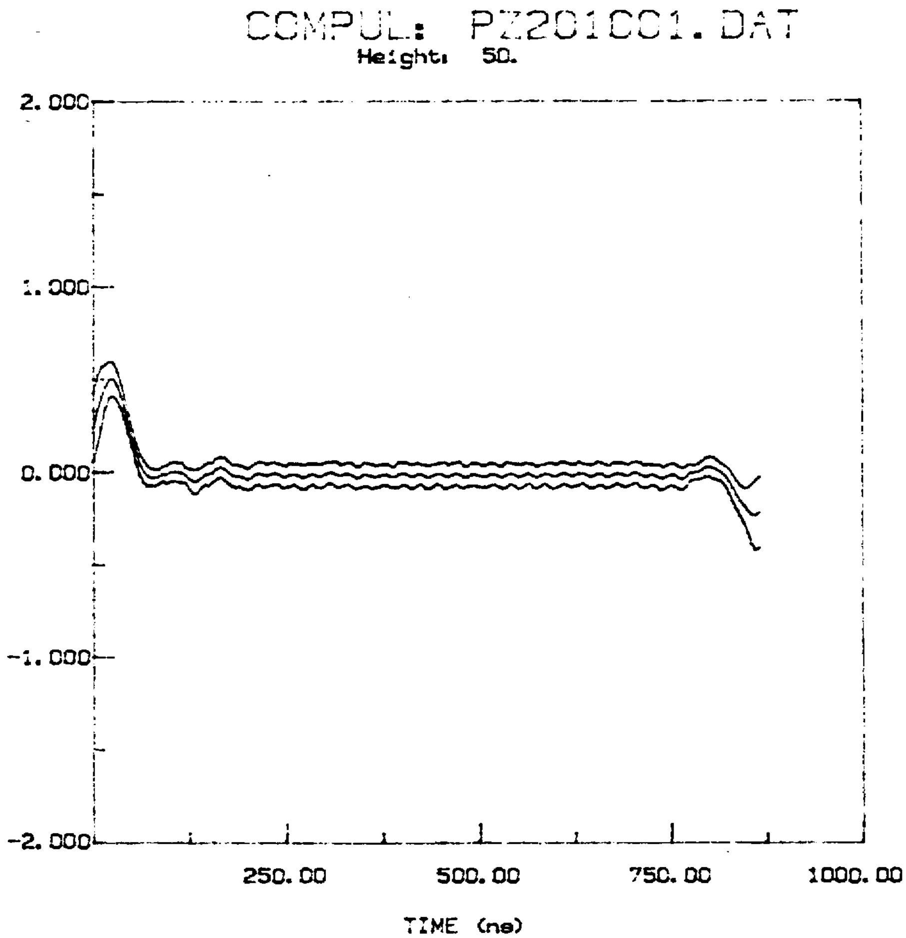


Figure 3A
- TEDSS data
- Software detected A.M.
- Preselectors bypassed
- 2 Ghz RF input

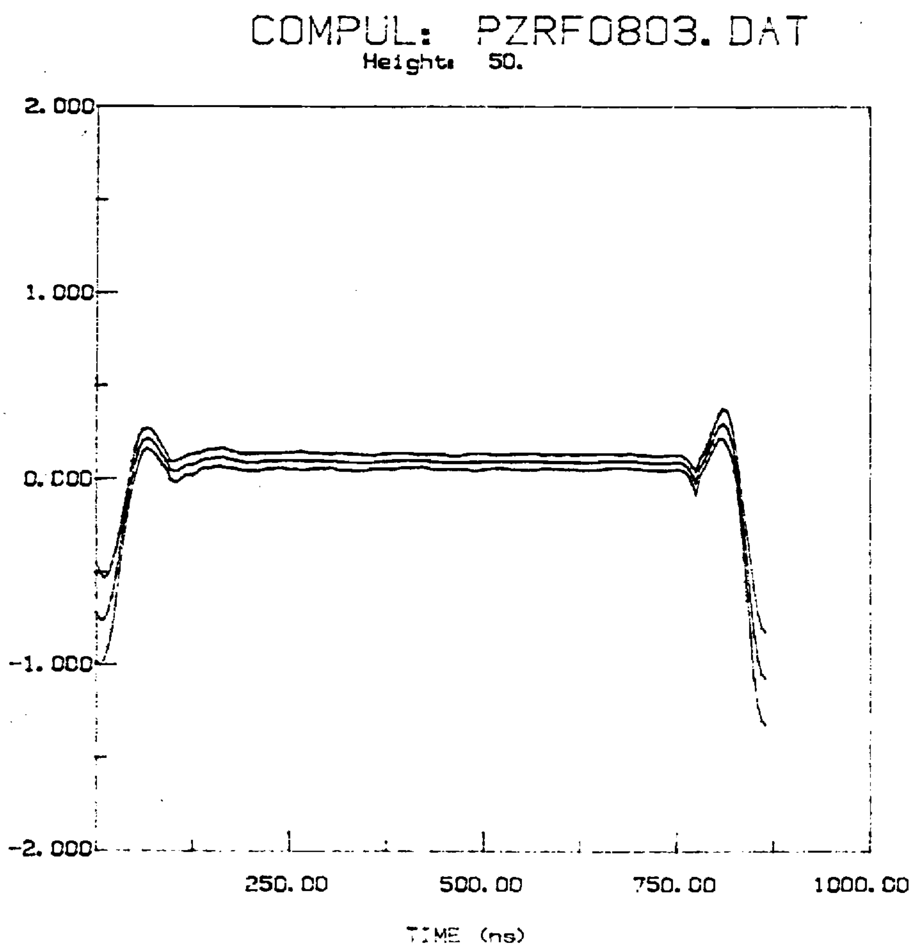


Figure 3B
- RADC data
- Software detected A.M.
- Preselectors bypassed
- 2 Ghz RF input

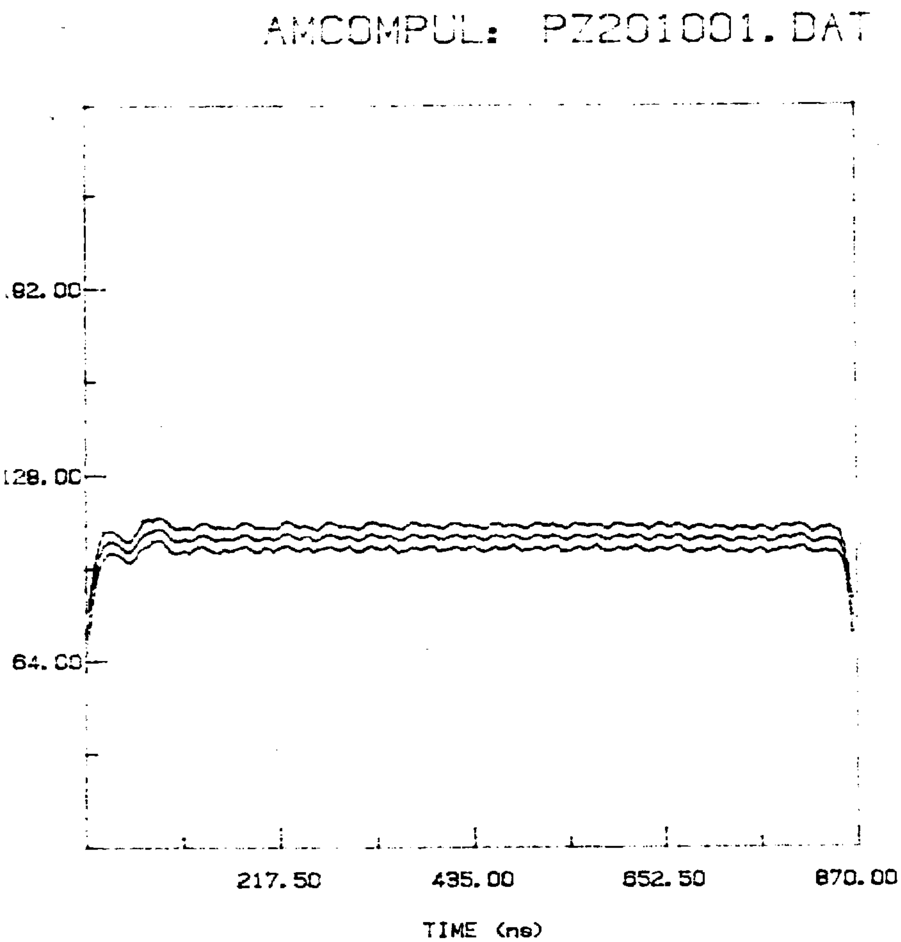


Figure 3C
- TEDSS data
- Software detected F.M.
- Preselectors bypassed
- 2 Ghz RF input

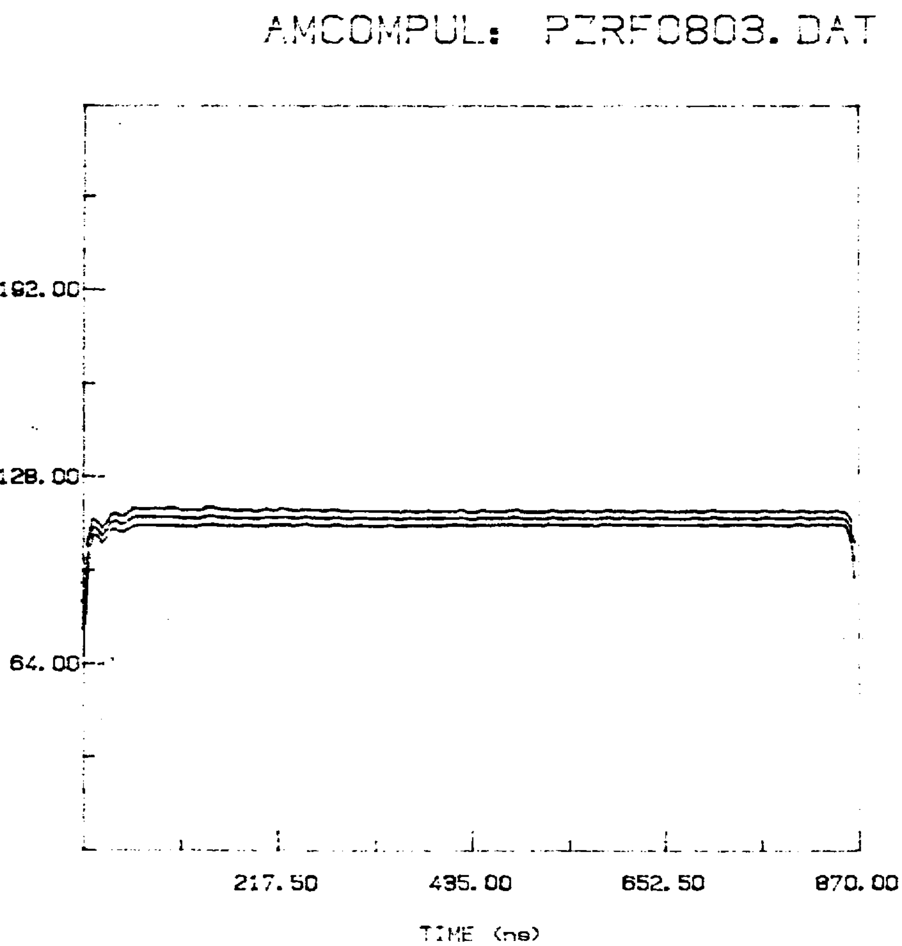


Figure 3D
- RADC data
- Software detected F.M.
- Preselectors bypassed
- 2 Ghz RF input

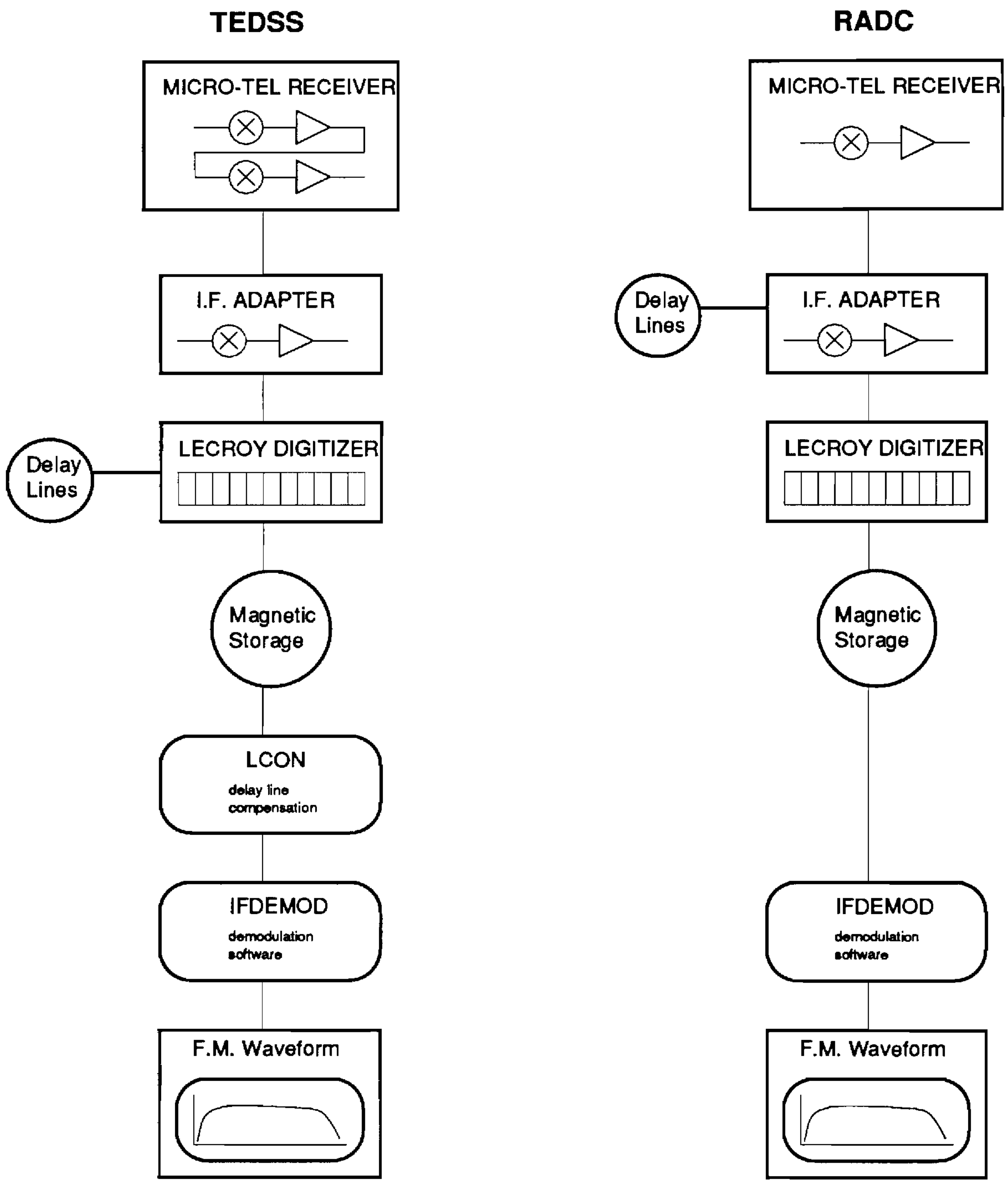


Figure 4

Data Flow Diagram for TEDSS and RADC Systems

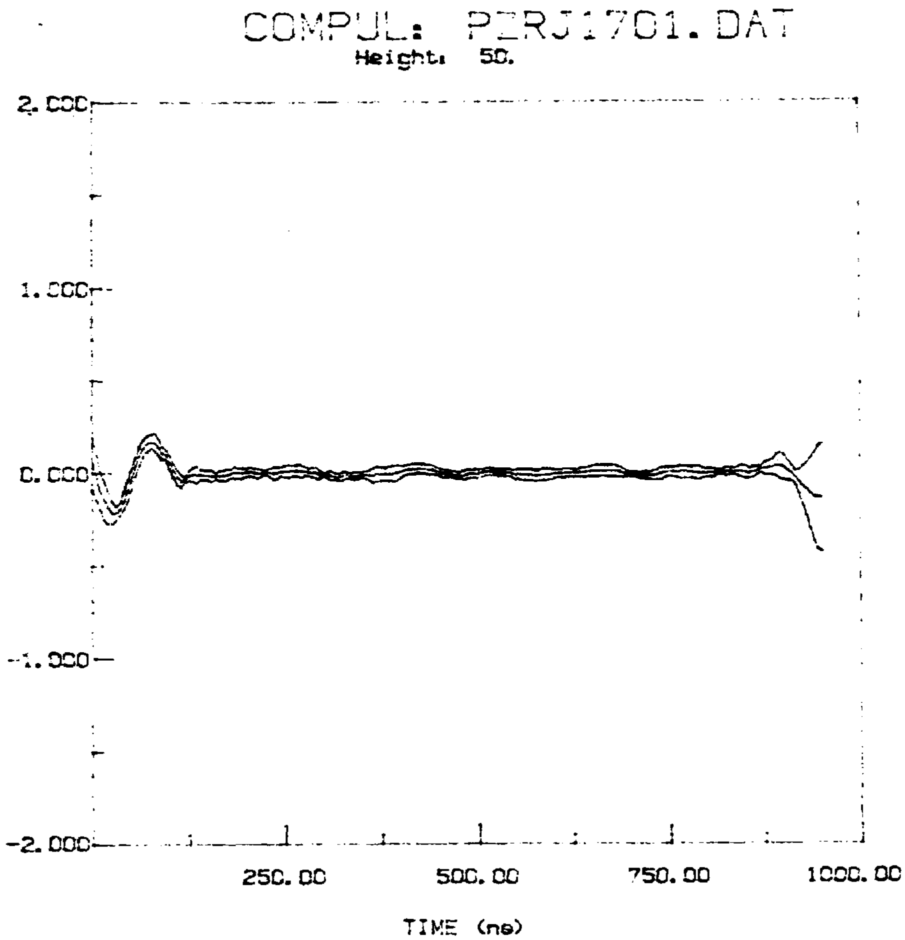


Figure 5A
- •RADC data
- •Software detected F.M.
- •Preselectors inline
- •2 Ghz RF input
- •Before filtering

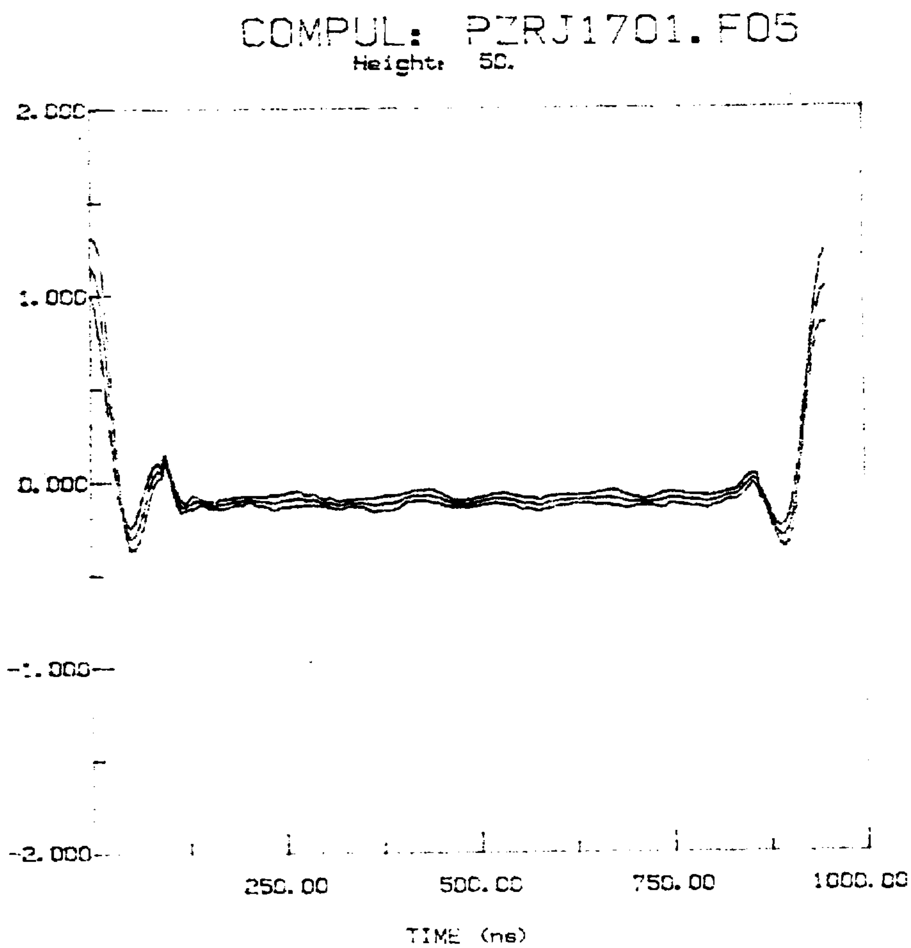


Figure 5B
- •RADC data
- •Software detected F.M.
- •Preselectors inline
- •2 Ghz RF input
- •After filtering

15GHz

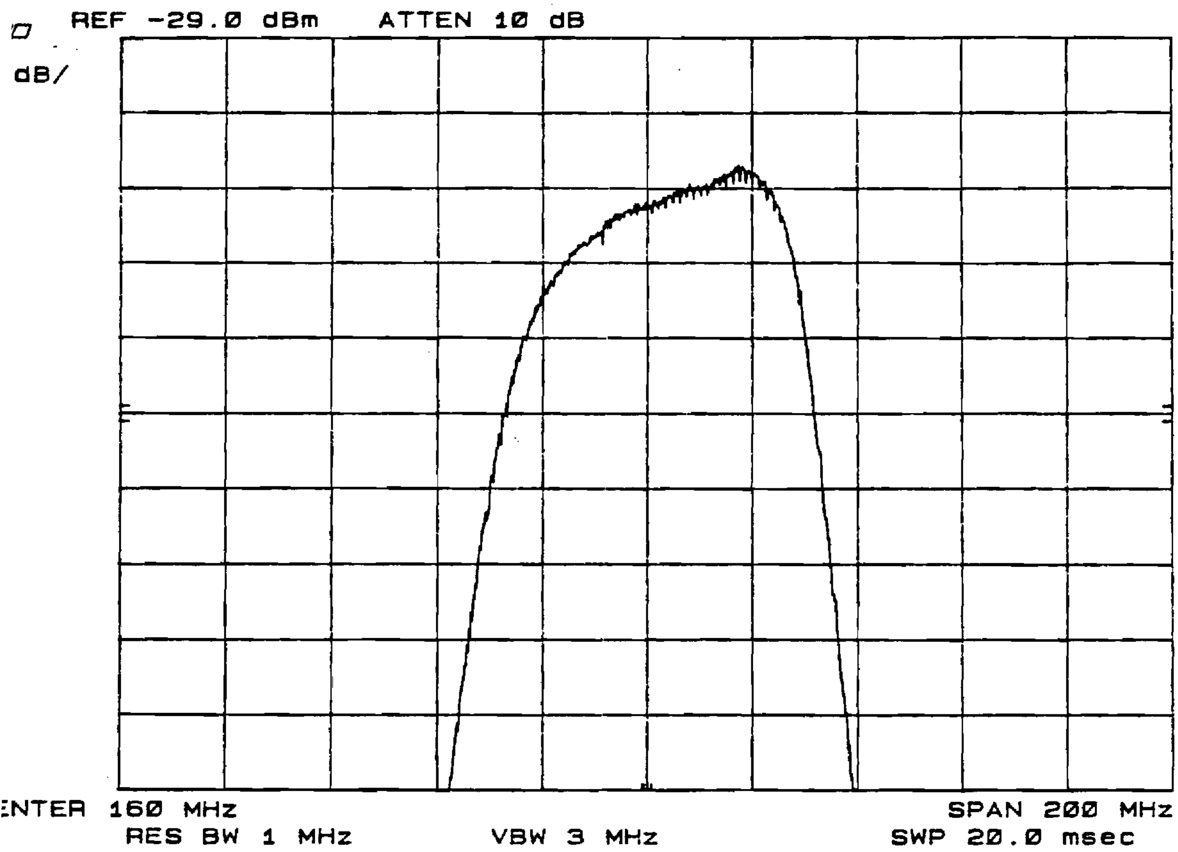


Figure 6A
- •TEDSS receiver passband
- •Preselectors bypassed
- •15 Ghz RF input

RADC
15 GHZ

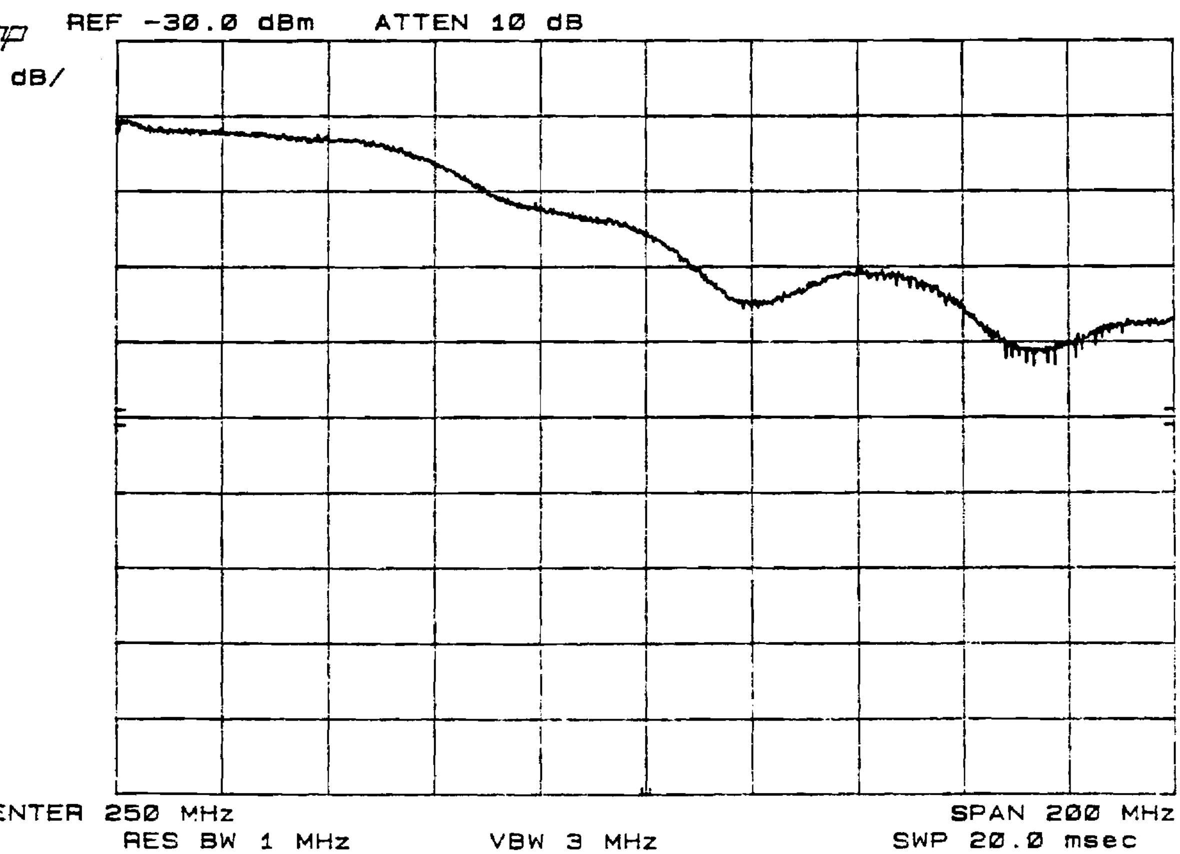


Figure 6B
- •RADC receiver passband
- •Preselectors bypassed
- •15 Ghz RF input

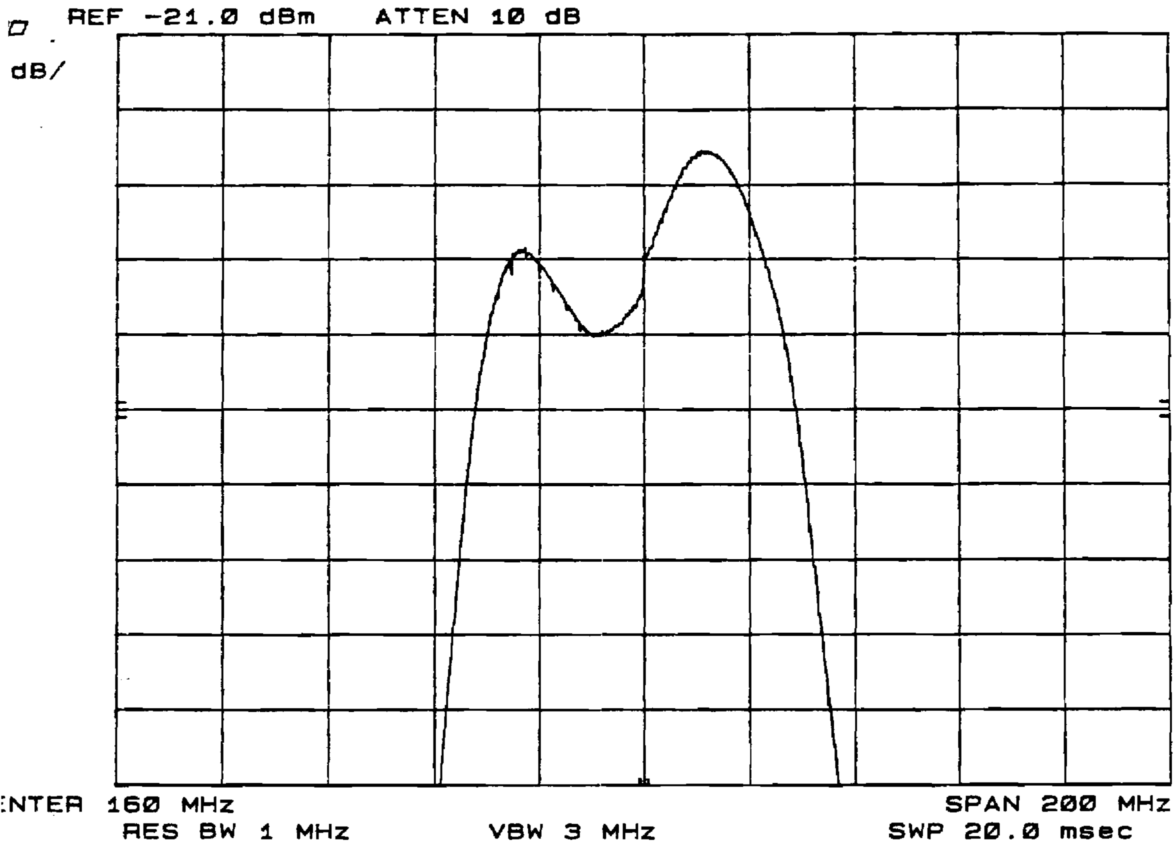


Figure 7A
- •TEDSS receiver passband
- •Preselectors bypassed
- •2 Ghz RF input

RADC
2 GHz

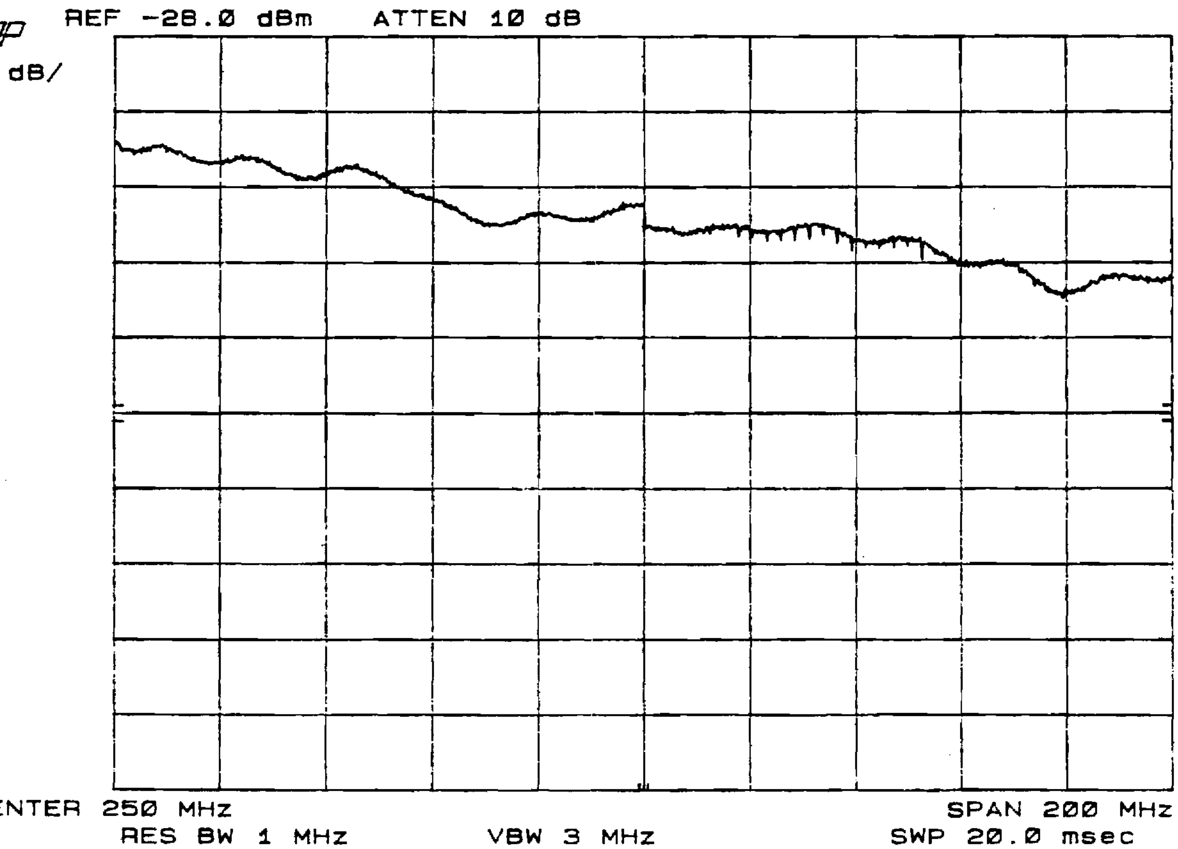


Figure 7B
- •RADC receiver passband
- •Preselectors bypassed
- •2 Ghz RF input

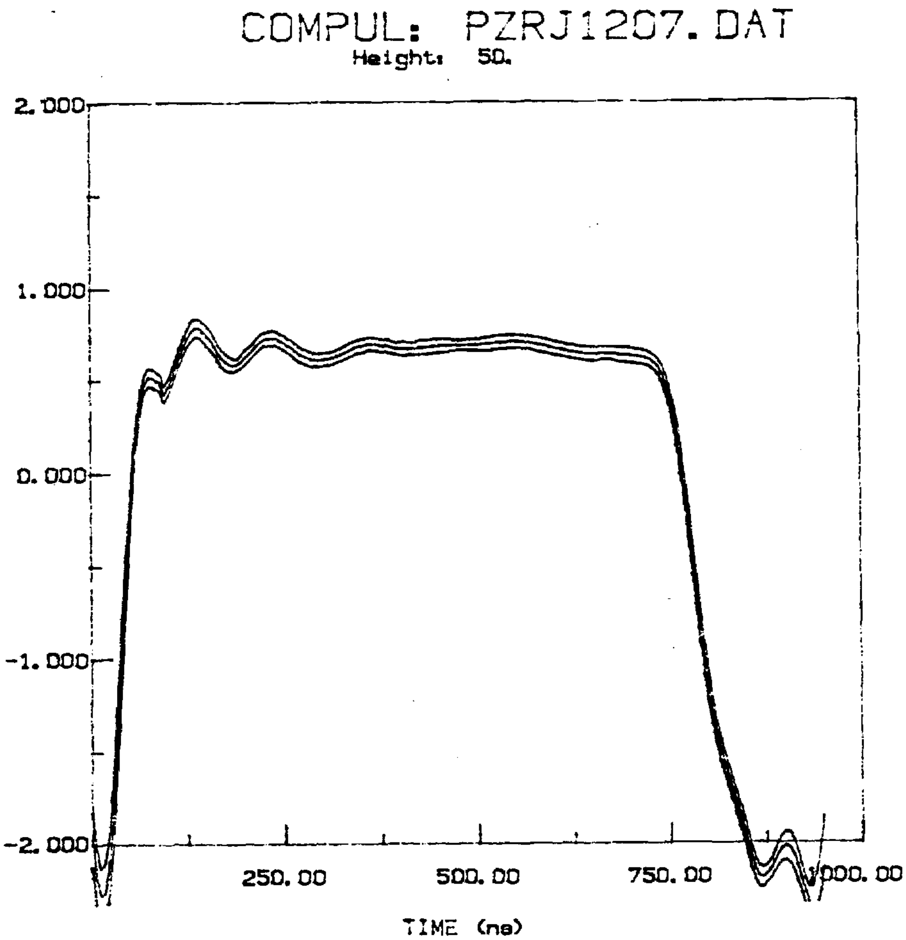


Figure 8A
- •RADC data
- •Software detected F.M.
- •Preselectors inline
- •2840 Mhz RF input
- •Full 50 Mhz BW

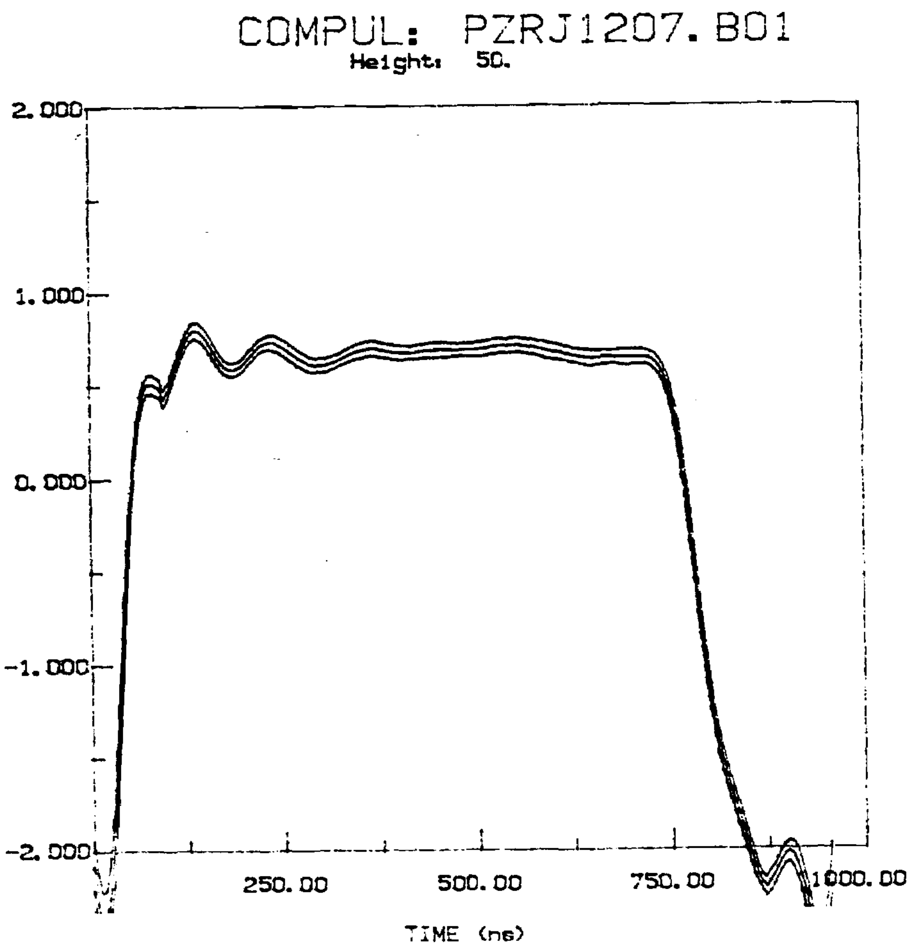


Figure 8B
- •RADC data
- •Software detected F.M.
- •Preselectors inline
- •2840 Mhz RF input
- •40 Mhz BW

PROBABILITY OF IDENTIFICATION MATRIX

BASIS: MINIMUM ENTROPY APPROACH

TRAINING SET FILE: KL&MERIB.DAT
DIMENSIONALITY OF FEATURE VECTORS = 16
SAMPLE INTERVAL (nsec.) = 5
FIRST SAMPLE LOCATION (%) = 50.00000
NO# OF FEATURES USED = 16

IDENTIFICATION ASSIGNMENT

SOURCE	DELAY	START	AVG.	TR. SET: 116008	140008	143008	102008
			TR. SET SIZE:	20	20	20	20
			DELAY (ns):	0	0	0	0
			TR. SET TYPE:	I.F.	I.F.	I.F.	I.F.
008.DAT	0	21	1	.00	.00	.00	100.00
207.DAT	0	21	1	.00	.00	.00	100.00

Figure 9

- Confusion Matrix
- Pulse sources are Hartsfield data from both systems
- Library contains three random TEDSS i.d. vectors and TEDSS i.d. vector for TEDSS file "PZ102008.DAT"

PROBABILITY OF IDENTIFICATION MATRIX

BASIS: MINIMUM ENTROPY APPROACH

TRAINING SET FILE: KL&MERIC.DAT
DIMENSIONALITY OF FEATURE VECTORS = 16
SAMPLE INTERVAL (nsec.) = 5
FIRST SAMPLE LOCATION (%) = 50.00000
NO# OF FEATURES USED = 16

IDENTIFICATION ASSIGNMENT

SOURCE	DELAY	START	AVG.	TR. SET: 116008	140008	143008	RJ1207
			TR. SET SIZE:	20	20	20	20
			DELAY (ns):	0	0	0	0
			TR. SET TYPE:	I.F.	I.F.	I.F.	I.F.
008.DAT	0	21	1	72.44	.00	.00	27.56
207.DAT	0	21	1	.00	.00	.00	100.00

Figure 10

- Confusion Matrix
- Pulse sources are Hartsfield data from both systems
- Library contains three random TEDSS i.d. vectors and RADC i.d. vector for RADC file "PZRJ1207.DAT"

PROBABILITY OF IDENTIFICATION MATRIX

BASIS: MINIMUM ENTROPY APPROACH

TRAINING SET FILE: KL&MER1A.DAT
DIMENSIONALITY OF FEATURE VECTORS = 16
SAMPLE INTERVAL (nsec.) = 5
FIRST SAMPLE LOCATION (%) = 50.00000
NO# OF FEATURES USED = 16

IDENTIFICATION ASSIGNMENT

SOURCE				116000	140000	143000
	TR. SET SIZE:			20	20	20
	DELAY (ns):			0	0	0
	TR. SET TYPE:			I.F.	I.F.	I.F.
	DELAY	START	AVG.			
2008.DAT	0	21	1	100.00	.00	.00
1207.DAT	0	21	1	100.00	.00	.00

Figure 11

- Confusion Matrix
- Pulse sources are Hartsfield data from both systems
- Library contains three random TEDSS i.d. vectors

PROBABILITY OF IDENTIFICATION MATRIX

BASIS: MINIMUM ENTROPY APPROACH

TRAINING SET FILE: KL&MER1D.DAT
DIMENSIONALITY OF FEATURE VECTORS = 16
SAMPLE INTERVAL (nsec.) = 5
FIRST SAMPLE LOCATION (%) = 50.00002
NO# OF FEATURES USED = 16

IDENTIFICATION ASSIGNMENT

SOURCE	TR. SET:			116000	140000	143000	102008	RJ1207
	TR. SET SIZE:			20	20	20	20	20
	DELAY (ns):			0	0	0	0	0
	TR. SET TYPE:			I.F.	I.F.	I.F.	I.F.	I.F.
	DELAY	START	AVG.					
2008.DAT	0	21	1	.00	.00	.00	95.21	.79
1207.DAT	0	21	1	.00	.00	.00	.00	100.00

Figure 12

- Confusion Matrix
- Pulse sources are Hartsfield data from both systems
- Library contains three random TEDSS i.d. vectors, a RADC i.d. vector for RADC file "PZRJ1207.DAT" and a TEDSS i.d. vector for TEDSS file "PZ102008.DAT"

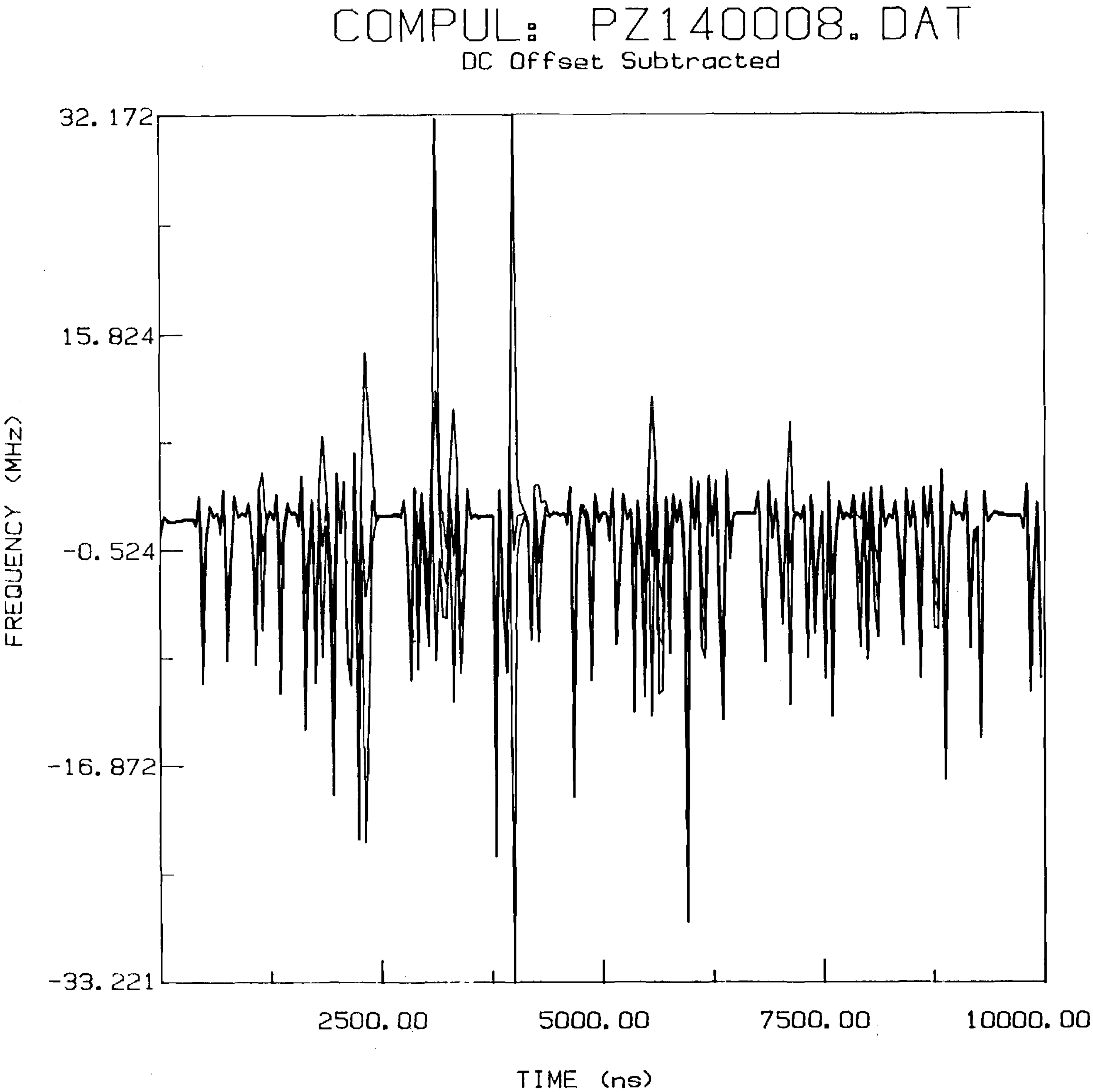
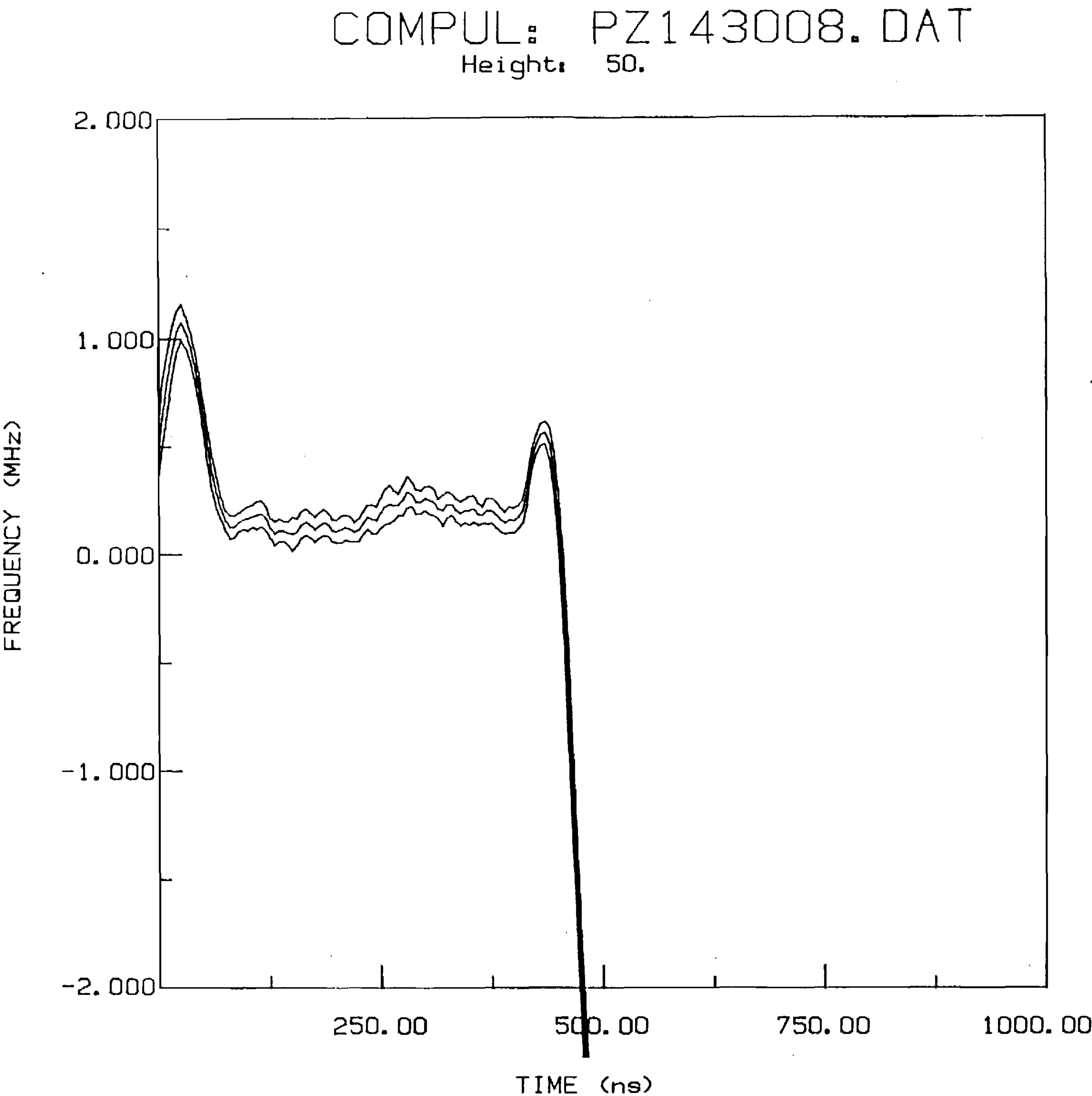


Figure 13
•TEDSS data
•Software detected F.M.
•One of the random library entries for the confusion matrix



<u>Figure 14</u>

- TEDSS data
- Software detected F.M.
- One of the random library entries for the confusion matrix

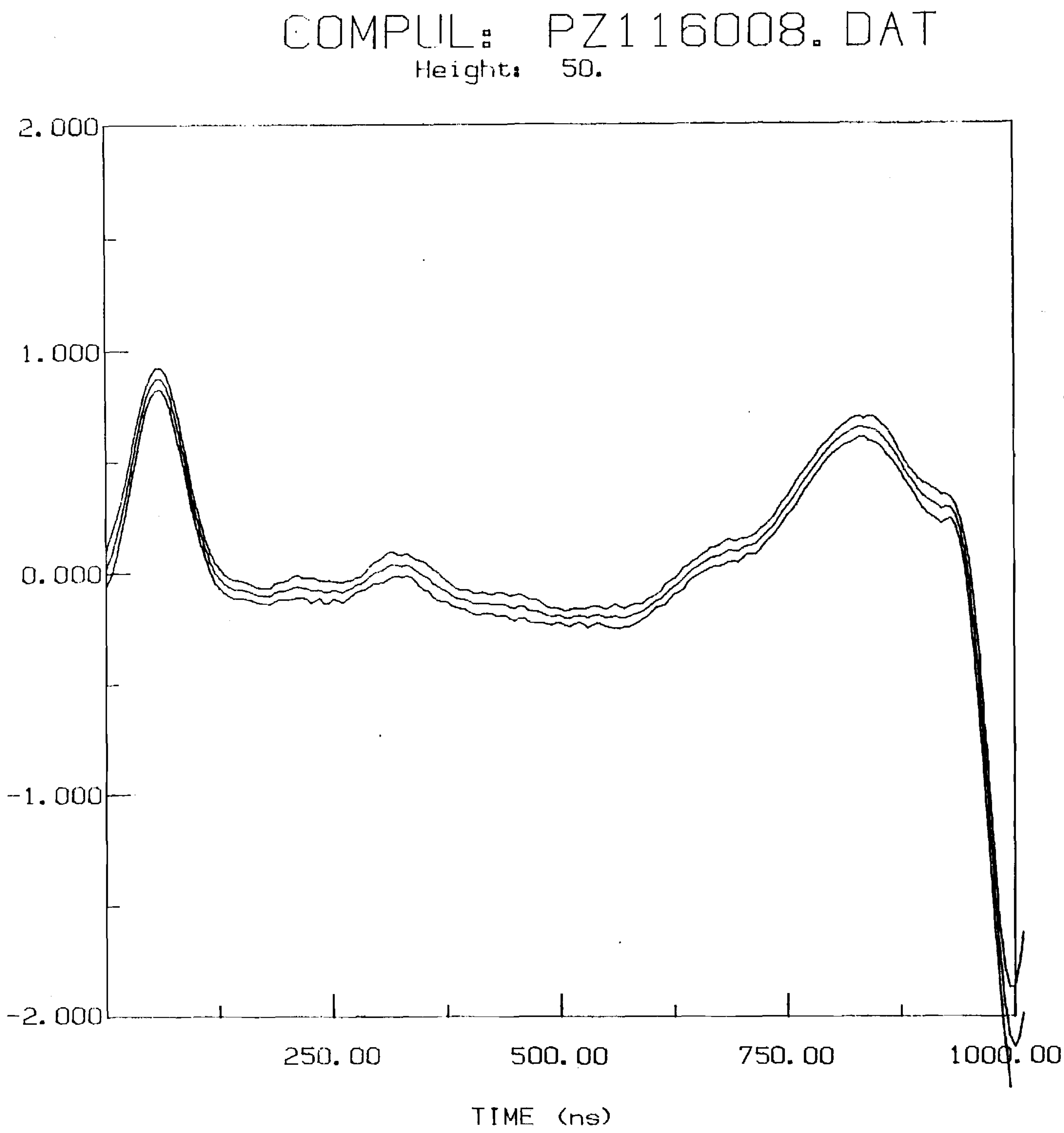


Figure 15
- TEDSS data
- Software detected F.M.
- One of the random library entries for the confusion matrix

B. TRAVEL:

None.

C. PRESENTATIONS AND PUBLICATIONS:

None.

D. LEVEL OF EFFORT BY EACH CONTRIBUTOR (IN MAN-MONTHS OR MAN-HOURS)

R. E. Willoughby	0.88 MM
C. J. Field	1.95 MM
W. Scott Petty	0.19 MM
M. M. Foreman	0.9MM
J. L. Lansford	0.1MM
K. L. Schlag	0.2MM